Report to the Congress
on the
STRATEGIC DEFENSE INITIATIVE

1985

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SECTION I

INTRODUCTION

A. PURPOSE OF REPORT

This report describes the coordinated Department of Defense (DoD) research and technology efforts needed to meet the goals of the President's Strategic Defense Initiative (SDI). It is in response to various Congressional requirements, including Section 1102 of the Department of Defense Authorization Act, Fiscal Year 1985, (Public Law 98-525, October 19, 1984), and the Report on the Department of Defense Appropriations Act, Fiscal Year 1985, of the House Committee on Appropriations (House Report No 98-1086, October 10, 1984). This report has been coordinated with the appropriate Departments and Agencies of the U.S. Government.

B. SCOPE

This report encompasses the plans for current and future efforts by the DoD to achieve the goals of the SDI. It describes the Strategic Defense Initiative Program executed by the Military Departments, Defense Agencies and the Strategic Defense Initiative Organization (SDIO). The basic program is applicable to all SDI supported research and technology efforts leading to decisions on whether or not to implement a defensive strategy and pursue development of promising architectures for defense against ballistic missiles. This plan is designed as a basic tool in communicating a broad overview of the SDIO Program to non-SDIO agencies and groups.

SECTION II

BACKGROUND

A. INITIAL DEFINITION EFFORTS

In March 1983, the President called for an intensive and comprehensive effort to define a long-term research program with the ultimate goal of eliminating the threat posed by nuclear ballistic missiles. Two study teams were established, the Future Strategic Strategy Study (FS^3) Team and the Defensive Technology Study Team (DTST).

- The FS^3 team examined the potential role that defense against ballistic missiles could play in the future in enhancing U.S. and Allied security.

- The DTST defined, in a Technology Plan, a long-term research and development program aimed at an ultimate goal of eliminating the threat posed by ballistic missiles.

The DTS, commonly referred to as the Fletcher Study, concluded that powerful new technologies are becoming available that justify major new development efforts to provide future technical options for defense against nuclear ballistic missiles. The study called for the structuring of a broad-based research effort focused on establishing technical feasibility, as opposed to initiating system level development. The recommended effort was structured to permit a decision in the early 1990s on whether to proceed to system level development.

The FS^3, which paralleled the Fletcher Study, concluded that defense against ballistic missiles could make important contributions to our national security. The study recognized that the exact nature of these contributions could not be resolved until more is known about the technical characteristics and capabilities of defense systems. Nonetheless, the studies concluded that it was essential that options for the deployment of advanced defenses against the ballistic missile be established and maintained. Such defenses could offer an entirely new concept of deterring nuclear war based on defense against attack rather than solely relying on retaliation. Equally important, the FS^3 concluded that research acts as a hedge against Soviet success in this field. Finally, FS^3 identified criteria for treaty compliant research.

B. FORMATION OF THE STRATEGIC DEFENSE INITIATIVE PROGRAM

In January 1984, a research program based on the Fletcher Study was established as the Strategic Defense Initiative. The SDI is a comprehensive program established to explore and demonstrate key technologies associated with concepts for defense against ballistic missiles. The Defensive Technologies Study (DTS) was used as a general guide for initiating the program. Principal emphasis was placed on technologies involving nonnuclear kill concepts. (Research on nuclear directed energy weapons is undertaken to develop an understanding of the potential of this technology and as a hedge against Soviet work in this area.)

Specific research efforts were organized in five areas:

- Surveillance, acquisition, tracking, and kill assessment (SATKA)
- Directed energy weapons (DEW) technologies
- Kinetic energy weapons (KEW) technologies
- Systems concepts; battle management (SC/BM)
- Survivability; lethality; and key technologies (SLKT)

The DTST, after identifying the technology activities needed to determine that a robust defense against a responsive ballistic missile threat is possible, projected the cost and schedules for two programs:

- A funding-limited program that proceeded at a rate supported by the Service and Agency funding allocated to the programs that predated SDI and were subsumed into it, and

- A program that proceeded at a technology-limited pace to provide the opportunity for decision in the early 1990s.

The technology-limited pace was selected.

For this technology-limited pace the DTST recommended $2385 million for the first year of the SDIO research and technology efforts. The FY 1985 budget request by the DoD limited this initial year to $1777 million while planning to reach the DTS recommended pace in FY 1986.

C. ACCOMMODATING FY 1985 RESOURCE CUTS

In the FY 1985 Appropriations Conference Report (98-1159), the conferees of the House and the Senate agreed to a general reduction for the SDI program from the President's budget request of $1777 million to $1400 million. After careful consideration of the alternatives, the Strategic Defense Initiative Organization reallocated the available funds in a manner that attempted to minimize the negative effect of the reduction on the overall goals and objectives of the program. A primary criterion used by the SDIO in reallocating resources was that technological questions must be provided with answers based on solid research in order to permit a valid assessment of the full potential of defensive systems. In making the adjustment necessary to meet the appropriation by Congress, the SDIO applied an overall strategy to maintain as best as possible the program goals, time lines, and tasks described to Congress in 1984 testimony. This reduction logic, first, ensured that in FY 1986 the program will be in a posture to reach the pace and scope planned at the program's inception. An effort was made to minimize the cost impact on existing programs. Then, major adjustments were implemented on certain programs inherited by the SDI that needed to be restructured to satisfy SDI needs. For most new starts implementation was delayed. For existing programs the SDIO frequently either delayed program enhancements or stretched

out or temporarily interrupted the flow, when it was possible, without interrupting continuity. Finally, some programs were continued at the planned pace, because they are fundamentally important to the decisions that must be made in these early stages of the program.

While the DoD was generally successful in meeting its overall strategy, achieving the planned funding levels in FY 1986 has become much more important if the program is to continue the goals, time lines, and tasks of the SDI. Since FY 1985 is the first year of the Initiative, the SDIO was able to minimize program delays by slipping new starts on a month-by-month schedule. In making these adjustments, the SDIO was cognizant of the fact that slipping efforts completely into the next fiscal year is often unwise, because potential, continuing resolution constraints and the normal contracting process could add several months of additional delay.

Reallocation difficulties were exacerbated by the fact that the FY 1985 reductions were significant (21%). The SDIO was reluctant to cut back those programs which are not only a necessary part of the SDI, but also are required for other programs (such as improved missile attack detection and warning programs). The FY 1985 reductions were clearly detrimental.

SECTION III

SDI GOALS, DEFENSIVE OPTIONS AND TECHNICAL OBJECTIVES

A. INTRODUCTION

Deterrence of nuclear war is the cornerstone of U.S. national security policy. Achieving a long-term, stable deterrence in the face of a growing nuclear threat has been, and will continue to be, a major foreign policy and military objective of the United States. Since the 1960s, U.S. strategy for maintaining that deterrence has been to field offensive nuclear forces that are capable of effective retaliation after absorbing a first strike directed at those forces.

If the large current Soviet investment in both offensive and defensive capabilities continues, it could destroy the foundation upon which the policy of deterrence has rested for several decades. The President, in establishing the Strategic Defense Initiative, recognized these trends and saw new opportunities in emerging defensive technologies to enhance deterrence and stability.

B. GOAL OF THE STRATEGIC DEFENSE INITIATIVE

The goal of the SDI is to conduct a program of vigorous research focused on advanced defensive technologies that may lead to strategic defense options that could:

- Support a better basis for deterring aggression;
- Strengthen strategic stability;
- Increase the security of the United States and its Allies; and
- Eliminate the threat posed by ballistic missiles.

The SDI seeks, therefore, to exploit emerging technologies that may provide options for a broader-based deterrence by turning to a greater reliance on defensive systems.

Since the President's speech in 1983, many have attempted to interpret what his vision entailed and what the SDI was expected to accomplish. Contrary to conflicting reports, the goal has not changed but has, in fact, remained consistent with the direction outlined by the President. The driving force behind his concept is freeing the world from the fear of nuclear conflict. It should be stressed that the SDI is a research program that seeks to provide the technical knowledge required to support a decision on whether to develop and later deploy advanced defensive systems. It is not a program to deploy those systems. All research efforts will be fully compliant with U.S. treaty obligations.

C. SDI PURPOSE AND POLICY

The President's Strategic Defense Initiative, (a White House pamphlet dated January 1985), makes clear the purpose of the SDI research program and the policy under which it is to be conducted. The purpose is described in the following way:

> "The President announced his Strategic Defense Initiative (SDI) in his March 23, 1983 address to the nation. Its purpose is to identify ways to exploit recent advances in ballistic missile defense technologies that have potential for strengthening deterrence—and thereby increasing our security and that of our Allies. The program is designed to answer a number of fundamental scientific and engineering questions that must be addressed before the promise of these new technologies can be fully assessed. The SDI research program will provide to a future President and a future Congress the technical knowledge necessary to support a decision in the early 1990s on whether to develop and deploy such advanced defensive systems."

> "As a broad research program, the SDI is not based on any single or preconceived notion of what an effective defense system would look like. A number of different concepts, involving a wide range of technologies, are being examined. No single concept or technology has been identified as the best or the most appropriate. A number of nonnuclear technologies hold promise for dealing effectively with ballistic missiles."

The stated policy for conduct of SDI is described as follows:

> "As directed by the President, the SDI research program will be conducted in a manner fully consistent with all U.S. treaty obligations, including the 1972 ABM Treaty. The ABM Treaty prohibits the development, testing, and deployment of ABM systems and components that are space-based, air-based, sea-based, or mobile land-based. However, as Ambassador Gerard Smith, chief U.S. negotiator of the ABM Treaty, reported to the Senate Armed Services Committee in 1972, that agreement does permit research short of field testing of a prototype ABM system or component. This is the type of research that will be conducted under the SDI program."

D. IDENTIFYING DEFENSIVE OPTIONS

The U.S. is taking steps necessary to underwrite stability in the near term via the President's strategic modernization program of offensive forces and our complementary arms reductions negotiations. Even as this is done, the nature of stable deterrence in the future must also be considered. In looking to this future, it is instructive to consider the experiences of the past. It has been alleged that the introduction of defenses into our overall strategic mix would overturn the principles of deterrence that have worked

for 35 years. This thesis not only fails to take the history of the nuclear age into account but also rests on an inaccurate definition of the concept of deterrence. For the first four years of the nuclear era, the U.S. had a monopoly and was invulnerable to nuclear attack. For the next ten years, the only Soviet nuclear weapon delivery capability that threatened the U.S. was the bomber, and the U.S. maintained an extensive air defense network against it. Air defenses were deemphasized with the advent of Soviet ballistic missiles. It made little sense to defend against bombers when the major threat faced by the U.S. became the intercontinental ballistic missile (ICBM)—a threat against which we had no effective defense. Since then, many have come to view deterrence solely in terms of offensive capability. But strategic defenses offer the hope for creating a better, more stable basis for deterrence.

In pursuing strategic defenses, the U.S. goal has never been to eventually give up the policy of deterrence. With defenses, the U.S. seeks not to replace deterrence, but to enhance it. Furthermore, the United States does not view defensive measures as a means of establishing military superiority. Because the U.S. has no ambitions in this regard, a deployment of defensive systems would most usefully occur in the context of a cooperative, equitable, and verifiable arms control environment that regulates the offensive and defensive developments and deployments of the United States and Soviet Union. Of course, if a shift were made to a different and enhanced basis for deterrence, careful consideration must be given to preserving a stable environment. There are no plans to place U.S. reliance on new capabilities until it is known that they can work. That is what the SDI is all about—answering the fundamental scientific and engineering questions that must be addressed before the promise of these new technologies can be fully assessed.

E. ACHIEVING A TECHNICAL CAPABILITY

If the SDI is to offer a high confidence basis for decisions to pursue one or more defensive options, the research program must do several things. It must conduct a broad-based research effort that expands and accelerates the progress of the relevant technologies. It must identify and evaluate the potential effectiveness of candidate ballistic missile defenses that could be assembled and deployed from those technologies. It must provide a basis for showing how those defense options can be operated and maintained to do the job. Finally, all research activity must be conducted in accordance with applicable U.S. treaty obligations. (See Appendix B for compliance of the SDI with the ABM Treaty.)

To achieve the major SDI goal, the SDIO must bring along the emerging technologies in a logical, timely way in this the initial stage of the SDI. The overall research task is expected to bring the technologies to maturity in three developmental thrusts: First, the most mature technologies need to be validated to provide initial options based on defense architectures that are affordable, survivable, and effective. A decision to proceed to this initial step would implement a defense against the threat the U.S. believes will be in place at least until early in the next century. Alternatively, the decision could be to reserve these options as a simple hedge against Soviet breakout and deployment of a defense against U.S. ballistic missiles.

Second, the long-term viability of future defensive options needs to be ensured by demonstrating the feasibility and readiness of technologies to support more advanced defense options. And third, research needs to be conducted that encourages the innovation by the U.S. scientific community in a response to the President's challenge to aid SDI research in identifying new approaches for eliminating the threat of ballistic missiles.

To support future decisions on defensive options, diverse efforts producing essential answers to critical issues must converge. Affordable ballistic missile defense architectures must be identified. The technical feasibility and readiness for development of survivable and cost-effective systems capable of meeting and sustaining the performance needs of the architectures must be established. The doctrine and concepts of operation for applying the system elements of the preferred architectures must be formulated. Practical paths for implementing the strategy and deploying the needed defenses in the context of foreign relations and arms control must be defined.

F. THE TECHNICAL DEVELOPMENT PACE

A notional schedule for research and possible development and deployment would be comprised of four phases:

- The research program, begun by the President in his 1983 Initiative, would run into the early 1990s when decisions could be made by a future President and Congress on whether or not to enter into systems development. This research activity will be conducted within the constraints of our current treaty commitments.

- The systems development or full-scale development phase could begin as early as the 1990s, assuming a decision is made to go ahead. During this period prototypes of actual defensive system components would be designed, built, and demonstrated.

- A transition phase would be a period of incremental, sequential deployment of defensive systems. This phase could be designed so that each added increment would further enhance deterrence and reduce the risk of nuclear war.

- The final phase would be a period of time during which deployment of highly effective, multi-layered defensive systems would be completed and during which ballistic missile force levels could be brought to a negotiated nadir.

As a research program, SDI is focused on the first phase to bring defense options to the point where U.S. leaders, after consultation with the Allies, could make decisions on whether or not to proceed to the system development phase and subsequent deployment.

SECTION IV

THE RESPONSIVE THREAT

A. INTRODUCTION

SDI marks a departure in the U.S. approach to defense against ballistic missiles in that it is examining the feasibility of a system that could engage ballistic missiles and warheads along their entire launch-to-impact trajectories and support a defense of a wide range of assets, both military and civilian. In order to provide a basis for future SDI technology development, all the functions that a multi-layered defense system must possess need to be recognized, and the required performance at the component level needs to be assigned. These component characteristics and required performance are based on estimates of present and future threats to be defended against and judgments of possible near- and far-term responses to a U.S. strategic defense deployment designed to limit the effectiveness of such deployments. This brief section provides a discussion of the approach the SDIO will use in providing a comprehensive and impartial assessment of the evolution of the responsive threat.

B. DEFINING A RESPONSIVE THREAT

The methodology to be used in defining a responsive threat is a reiterative process (as graphically depicted in Figure IV.1). First, the present estimates of capability in ballistic missiles and trends in upgrading force structures represent a significant investment in national resources by an adversary. Such an investment will most likely not be abandoned nor will current commitments to enhance ballistic missile capabilities be abandoned to respond to an undefined U.S. defense based on what the U.S. can achieve with technology that can be developed in the near term. For this reason, the first task will be to define a series of defense architectures against the currently projected threat as a basis for subsequent countermeasure/counter-countermeasure analysis. Defense against current and near-term threats is not a trivial problem, and it will require the development of a broad range of stressing defensive technologies. By focusing on the near term, more advanced defense systems can be derived from architectures that are based on the minimum uncertainty in the threat and its characteristics. In addition, these architectures will be based on the minimum technological thresholds that must be exceeded if the defense system is to be viable. As a result, technically non-responsive system candidates can be rejected early. Finally, sufficient diversification of scenarios will be employed to explore fully the influence of attack strategies and tactics on the technical evolution of the SDI.

The reference architectures will then, based on U.S. understanding of an opponent's military doctrine, be used to identify potential responses and their impact on the architecture's performance. Effective responses will be evaluated for technical feasibility, capability of the adversary's existing technology base to support it, the development of additional capabilities, and the development time frame of an evolving responsive threat.

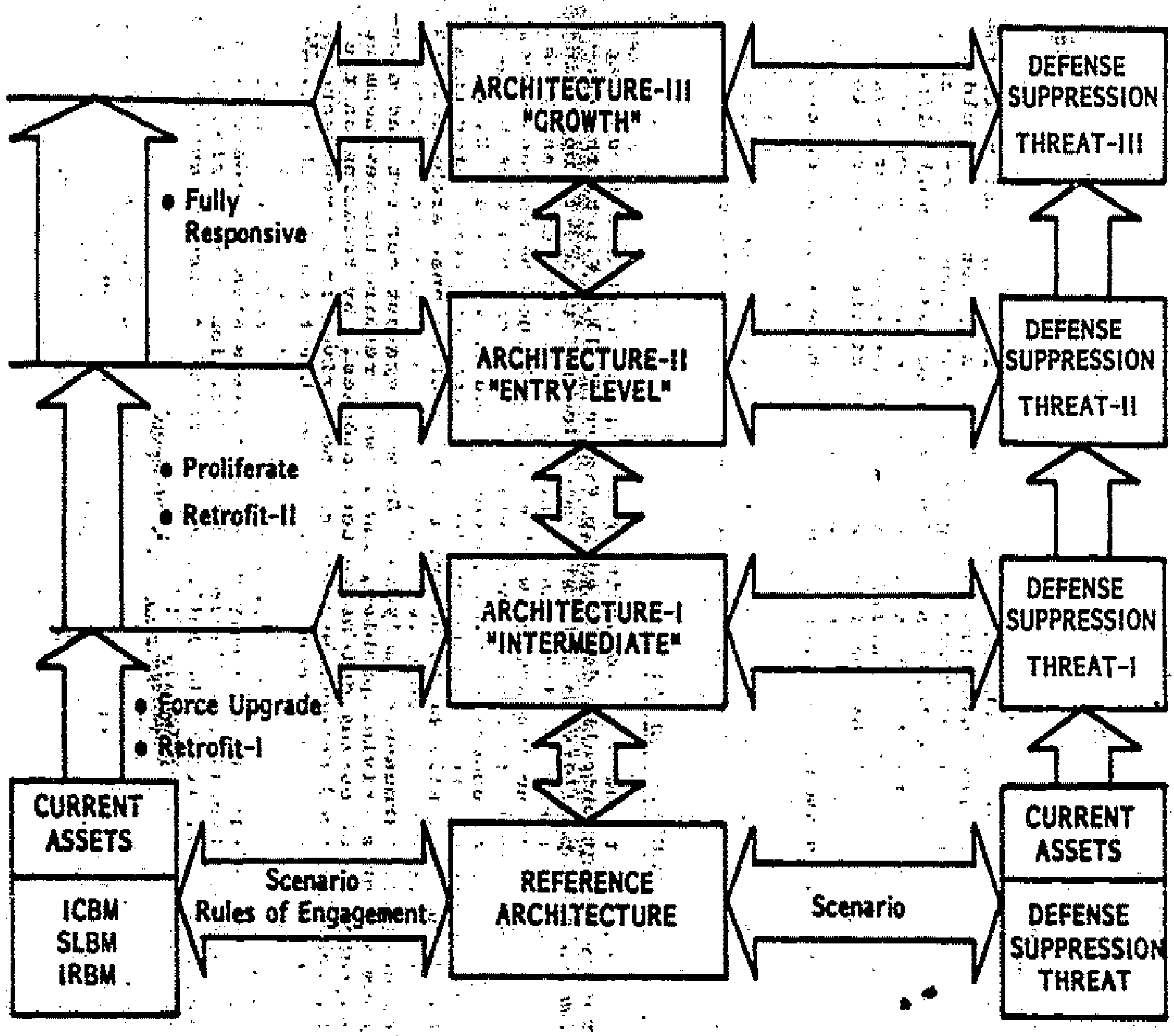

Figure IV.1. Responsive Threat Methodology

This first generation responsive threat can then be used to identify defensive architectures to overcome it. The responsive threat methodology can be processed again to refine SDI architectural capabilities such that the technology pace and required resources of the defense and this response favors the defense.

The ballistic missile threat of interest consists of ICBMs, SLBMs, IRBMs, MRBMs and SRBMs--intercontinental, submarine-launched, intermediate-range, medium-range, and short-range ballistic missiles--that could be targeted against the United States and its Allies. Over the next 20 years, the Soviets are expected to introduce qualitative improvements to their ballistic missile forces which would allow them to increase further their offensive strike capabilities. If ballistic missile force levels with multiple independently targeted reentry vehicles (MIRV) were no longer constrained by arms control agreements, the number of Soviet ballistic missile warheads could increase to at least twice their current levels with only a modest increase in the number of ballistic missile boosters. While the U.S. pursues defensive technology development, there are a number of political and technical approaches that might be used in an attempt to negate any such development and deployment of a defense against ballistic missiles. In the near term, the Soviets might employ a concerted political and diplomatic effort, first to force the United States to drop or delay the plans of the SDIO or, failing that, to negotiate them away. Over the long term, if the U.S. moves ahead with plans to deploy a defensive system, the response would depend on an adversary's expectations for the U.S. deployment program. Responses that enhance an existing ballistic missile capability could include:

- Increasing missiles, warheads, and penetration aids in an attempt to saturate the defense;

- Upgrading ballistic missiles with new boosters and warheads to attempt to evade the defense;

- Reducing signatures of these systems and warhead deployment techniques and missile-basing schemes that would make them less detectable;

- Hardening or modifiying ballistic missiles to reduce their vulnerability to defensive weapons; and

- Developing weapon systems and attack options to attack the defense.

Since this range of potential responses is broad, and since the time scale of the proposed SDI effort extends beyond anyone's ability to make accurate forecasts, no great precision in evaluating a potential adversary's course of action can be claimed.

At the same time, threats postulated as a response to defensive architectures must be credible and could require major development and revisions to the current threats. Many changes are much more easily envisioned than put

into operation. Many of the responses postulated so far are unproven, will require nontrivial R&D, and might have a deleterious, and possibly unacceptably adverse impact on the offensive capability of the missile force.

Finally, consideration must be given to techniques to negate directly any U.S. defense force. The defense suppression threat consists of those military efforts that will be seeking to suppress the U.S. strategic defense force by lethal and nonlethal techniques. Such techniques range from simple but massive brute-force measures to more sophisticated and subtle methods. It is likely that a defense suppression threat could evolve from today's techniques and such a threat would be detectable during development and testing.

Defense suppression attacks should be considered in terms of their overall strategic implications. For example, attacks against orbital elements of the U.S. defense force would have different implications than attacks on ground-based elements which could be considered to be an attack on the land masses themselves. Defense suppression attacks made on the U.S. defense force as a precursor to a strategic strike could significantly increase strategic warning time. Once the U.S. defense is in place, any attack on defended targets may entail allocation of a portion of the attacking force to defense suppression. Likewise, an attack against the U.S. strategic defense force which requires a large percentage of the adversary's strategic offensive strike capability cannot be considered realistic, as it would divert essential strike resources from other mission objectives.

SECTION V

FUNCTIONAL RELATIONSHIPS OF A DEFENSE AGAINST BALLISTIC MISSILES

A. OVERVIEW OF THE DEFENSE ENVIRONMENT

A typical ballistic missile trajectory can be divided into four phases:

- A boost phase when the first and second stage engines are burning and offering intense, highly specific observables;
- A post-boost phase, also referred to as bus deployment phase, during which multiple reentry vehicles (RVs) and penaids are being released from a post-boost vehicle (PBV);
- A midcourse phase during which RVs and penaids travel on ballistic trajectories above the atmosphere; and
- A terminal phase during which trajectories and signatures are affected by atmospheric drag.

Short-range submarine-launched ballistic missile (SLBM) and intermediate-range ballistic missile (IRBM) trajectories have boost and terminal phases similar to ICBMs but, in most cases, have less extensive busing and midcourse phases.

In a defense capable of engaging ballistic missiles all along their flight path, certain key functions must be performed:

- Rapid and reliable warning of attack and release of defense assets for engagement. This requires full-time surveillance of ballistic missile launch areas (potentially worldwide) to detect an attack and define its location, order of battle, and intensity as a function of time; determine likely targeted areas for confident initiation of the battle; and provide track data for handoff to boost-phase intercept and post-boost vehicle tracking systems.
- Efficient intercept of the booster and PBV. In performing this intercept and kill function, the defense must be capable of dealing with attacks ranging from a few tens of missiles to a massive, simultaneous launch requiring 10 or more kills per second by the defensive weapons in the battle. In attacking PBVs, the defense prefers to attack as early as possible to maximize the number of RVs killed per PBV kill and minimize the number of decoys and penaids deployed.
- Efficient discrimination in the post-boost and midcourse phases through bulk filtering of lightweight penaids. This is required so that only expensive, space-consuming, heavy decoys stress the defense.

- Enduring birth-to-death tracking of objects in the threat cloud. This is required to permit long and multiple observations for discrimination and kill assessment and to enable unambiguous handover, with small error rates, of RVs to designated interceptors.

- Low-cost intercept in midcourse. The intercept and kill functions for a midcourse weapon involve recognition of the assigned target in the midst of a large array of penaids and junk, long-range delivery of the hit-to-kill vehicle to the vicinity of the target, terminal homing on the target, and collision with the target so that killing energy is delivered. In the case of beam weapons, pointing and dwell time on the target replace homing.

- High endoatmospheric terminal intercept. The terminal intercept and kill function involves relatively short-range delivery of warheads with sufficiently high performance to permit destruction at altitudes that are high enough to minimize damage on the ground due to salvage fuzing. A very fast interceptor is desired so that one can realize maximum benefit from atmospheric filtering of penaids and junk from the threat cloud. Terminal homing and fuzing complete the required functions.

- Efficient and timely battle management, communications, and data processing to coordinate and/or optimize use of defense resources for effectiveness and for economy of force are key to all phases.

- Timely kill assessment in all phases.

It is generally accepted, on the basis of many years of experience in applying air defense doctrine, study of defense against ballistic missiles, and experiments, that an efficient defense against a high level of threat would be a layered defense requiring all of the capabilities summarized above. For example, three independent layers, each of which allows 10 percent leakage, for an overall leakage of 0.1 percent, are likely to be less costly than a single layer that has the same leakage. Also, in the presence of boost-phase intercept, the attacker has great uncertainty whether the most important targets will be attacked, because he has no reliable way of predicting which boosters will be destroyed by the defense. This can be contrasted to the situation where only single coverage from terminal defenses exist and such defenses can first be exhausted and then the target attacked. The next few paragraphs describe the factors that dictate the use of multiple, complementary tiers. The discussion works backward through the ballistic missile trajectory to best illustrate the synergisms of a defense-in-depth.

The defended area of a terminal-defense interceptor is determined by how fast it can fly and how early it can be launched. Since terminal-defense interceptors fly within the atmosphere, their average velocity is limited. How early they can be launched depends on the requirements for discrimination of the target from penaids and accompanying junk and designation to the interceptor. A requirement for independent discrimination delays launch of the interceptor and reduces the footprint or defended area. Moreover, since the terminal defense of a large area requires many interceptor launch sites, the defense is vulnerable to saturation and

preferential offense tactics. Such structured, preferential attacks lead to a desire to complement the terminal defense with area defenses that intercept at long ranges. Such a complement is found in a system for exo-atmospheric intercepts in the midcourse phase.

Intercept outside the atmosphere forces the defense to cope with decoys designed to attract interceptors and exhaust the force. Fortunately, available engagement times are longer (approximately 1500 sec) than in other phases. This freedom from the tight time lines in boost (150 to 300 sec), post-boost (10 to 300 sec), or terminal (20 to 50 sec) phases strongly argues that a midcourse intercept system is an important element in a comprehensive defensive capability. The midcourse system must, however, provide both early filtering of nonthreat objects and continuing attrition of threat objects if the defense is to minimize the pressure on the terminal system. Since starting the defense process at midcourse accepts the potential of a tenfold to several hundredfold increase in targets from multiple independently targeted reentry vehicle (MIRV) and decoy deployment, intercept before midcourse is attractive.

For every booster with MIRV payloads killed, the number of objects to be handled by the remaining elements of a layered defense system is reduced by 10 to 100 or more. A very important additional feature is that such kills also disrupt the highly structured attacks that stress terminal systems. Ability to effectively respond to an unconstrained threat, therefore, is strongly dependent on the viability of a boost-phase intercept system. However, as noted earlier, a boost-phase system is faced with extremely short engagement times and potentially large numbers of targets. They dictate a weapons system that can deliver enough energy to each target in the limited available engagement time to ensure booster kill.

The phase of flight where PBV operations occur is treated as a separate case. This phase is potentially rich in information that can be used for discrimination. As this phase of flight proceeds, the leverage decreases as decoys and RVs are deployed. On the other hand, the post-boost phase offers up to 300 additional seconds for intercept by boost-phase weapons and may be the only phase accessible after certain Soviet boost-phase responses.

The natural and man-made phenomena and the required technology for each of these phases of a ballistic missile trajectory are different. Thus, it is useful to separate system concepts into these phases to discuss top-level performance goals, identify broad technical approaches to achieving those goals, and identify key issues to be resolved. The remainder of this section discusses these topics in the context of boost, post-boost, midcourse, and terminal defense systems. These discussions establish the basis for an investment strategy and for an analysis of the technology development needed to realize defense-in-depth concepts. These development needs are covered in the next section.

There is considerable overlap between phases, and some distinctions are made more for convenience in this discussion than because of major changes

in either phenomenology or technology. Furthermore, in each phase of a ballistic missile flight, a defensive system must perform the basic functions of threat detection, tracking, identification, intercept, destruction, kill assessment, coordination, and self-defense. These functions can conveniently be grouped under the headings of surveillance; target acquisition and tracking; weapon pointing and/or guidance; and energy delivery/-kill mechanisms.

B. FUNCTIONAL NEEDS OF THE BOOST PHASE (BOOSTER IGNITION TO INITIATION OF POST-BOOST VEHICLE OPERATIONS)

Functional needs and performance goals for defensive systems in boost-phase operations are highly sensitive to assumptions about the number of targets to be engaged as a function of time and/or assumed target vulnerability. The first assumption bounds the performance of the surveillance and target acquisition system, the battle management and data processing system, and the fire-control or weapon-guidance sensors. The second assumption (target vulnerability) has a major impact on the performance of the weapon. Both dictate the number of weapons required. Survival and endurance of boost-phase systems can be crucial.

- Surveillance. The requirement to detect launches and associate target signatures with specific booster tracks is fundamental. Once launch is detected, the system must be capable of handling large numbers of individual targets during the few hundred seconds or less of booster launch in the presence of natural interference from the sun and earth background, and, perhaps, active deception or countermeasures. This same surveillance system would provide handover to the midcourse tracking system that must acquire and track the PBV during its maneuvers and initiate birth-to-death tracking.

- Target Acquisition, Tracking, and Pointing or Weapon Guidance. Once the individual booster tracks have been identified, the battle management and C^3 system must allocate individual targets or groups of targets to a weapon or weapon platform. A sensor or sensors on or closely coupled to that platform must then acquire and track the cool body of the booster. The pointing accuracy required for this function can be quite stressing for some directed energy concepts. It can be relaxed for kinetic energy kill vehicles that have terminal homing and for some directed energy concepts.

- Energy Delivery Kill Mechanisms. Kill mechanisms must, in general, deliver from a few to tens of megajoules of energy to the booster or post-boost vehicle. Some weapons concepts attack targets serially using available battle time to move from target to target. In such systems, available retarget time is quite limited if required high kill rates are to be achieved. Other concepts engage targets in parallel and do not require rapid retargeting. Some concepts involve physically hitting the target with a homing warhead that must be terminally guided. Finally, one must sense, in near real time, whatever characteristic changes occur in the target that indicate that it has been successfully engaged.

C. FUNCTIONAL NEEDS OF THE POST-BOOST PHASE

The dispensing phase of a post-boost vehicle (PBV) begins at the end of booster burn and ends for each RV or penaid as it leaves the PBV or "bus". Accordingly, acquisition, tracking, and discrimination between RVs and decoys and debris are key functions that begin in this phase and continue into the midcourse phase. Since the target is the PBV, the target engagement and energy delivery functions are similar to those for boost phase.

- Surveillance. At booster burnout, the large, massive infrared signatures of the plume are replaced by the modest signatures of intermittent post-boost propulsion and the PBV body. If groups of objects can be classified, if a track file can be established for each group, and if the state vectors can be handed over to a birth-to-death tracker, the difficulty of discriminating RVs and masked RVs from other objects in later phases will be greatly reduced or the offense will be forced to use fewer, more complex decoys.

- Target Acquisition, Tracking, and Pointing or Weapon Guidance. The functional needs are essentially the same as for boost phase with some differences. For example, precision pointing now must be accomplished on bodies undergoing smaller but more frequently varying accelerations. While target signatures are much, much smaller than in boost phase, they should be large enough to support long-range acquisition and tracking.

- Energy-Delivery Kill Mechanisms. One would probably use boost-phase kill mechanisms in the PBV phase, although substantial differences in the vulnerability of PBVs and boosters are expected.

D. FUNCTIONAL NEEDS OF THE MIDCOURSE PHASE

Midcourse defense is the process of detecting and destroying an RV after its deployment from the PBV and before it reenters the atmosphere. Acquisition or handover, tracking, and discrimination are the key functions in continuing defense against ballistic missiles during this phase. With good discrimination, multiple engagement opportunities are available over the relatively long time of flight.

- Surveillance. An autonomous midcourse surveillance function requires sensors that detect all threatening objects in the midcourse regime, rapidly reject as many decoys and as much debris as possible, precisely track remaining credible objects (RVs and heavy decoys), discriminate the RVs, provide RV position and trajectory data of adequate accuracy for firing kill devices, and perform kill assessment. As in the PBV phase, groups of objects must be classified, track files established, and state vectors handed over.

- Target Acquisition, Tracking, and Pointing or Weapon Guidance. Precision tracking of designated objects is required to provide the position of the target needed for intercept. This consists of

trajectory predictions for battle management and handover to a midcourse hit-to-kill interceptor. In addition, position accuracy is needed for handover to acquisition, tracking, and pointing subsystems of directed-energy weapons.

- Kill Mechanisms. Since the targets (RVs) must be protected against the heat and forces of reentry, they are inherently hard to thermal and impulse kill mechanisms. For high confidence, kill mechanisms must deliver a few tens of megajoules of energy to the target. The long duration of the midcourse trajectory (1500 sec) offers opportunities for multiple engagements even with modest interceptor velocities.

E. FUNCTIONAL NEEDS OF THE TERMINAL PHASE

A terminal defense is sought which protects both urban/industrial and military targets against the residue of an attack that has been engaged in all previous phases of its trajectory. Additionally, a terminal-defense element of a total strategic defense system could serve three separate but similar functions. It could provide the final layer in a defense-in-depth system, stand-alone defense against depressed trajectory SLBMs, and stand-alone capability for defense of Allies. It is assumed in this discussion that terminal defense needs are defined to exploit the major increase in terminal defense capability possible from the attrition and discrimination in the boost and midcourse elements of the system.

The driving requirements for the terminal tier are survivable defense of targets that are easily damaged by nuclear weapons or soft targets (i.e., cities, industry, etc.) and an affordable system that can defend the entire United States. Defense of soft targets demands a keep-out altitude above which all RVs must be killed to prevent damage to such targets. The need to provide this keep-out altitude over the entire United States requires that the defense elements have large footprints, i.e., the area defended must be large in order to limit the number of elements needed for full coverage.

- Surveillance. In order to identify the small fraction of lethal RVs reaching the terminal tier intact in the midst of a large number of objects detected, the terminal-phase system must acquire and sort all objects as they arrive in the upper layers of the atmosphere. The system must be able to use atmospheric filtering to discriminate against reentry decoys and junk (i.e. spent PBVs, tankage, RV deployment hardware, and the debris created by destruction of targets in the late boost phase and midcourse flight). Such discrimination actions will be based, where possible, on handovers from the midcourse engagements. Nonetheless, terminal defense must maintain, as an autonomous final line of defense, a separate surveillance capability while being able to use previous track files (if they are available) for efficiency.

- Target Acquisition, Tracking, and Weapon Guidance. An interceptor must be committed to each threatening object and given data to perform a "space-point intercept", i.e., it flies to its assigned

point in space. On arrival at that point, the interceptor acquires its target on its seeker and homes to kill its target. Homing accuracies depend on the warhead used. In order to correct the seeker-handover error in the very short time available, the homing vehicles must have good maneuver capability and very fast control system response.

Intercept and Kill. The interceptor must have very high acceleration and burnout velocity. For targets that require the interceptor to fly a considerable distance, the intercept will take place near the required keep-out altitude. The high velocity of the interceptor permits it to have a relatively large footprint (defended area).

SECTION VI

PROGRAM OVERVIEW

A. THE RESEARCH AND TECHNOLOGY (R&T) PROGRAM

To provide the technological solutions needed, the SDI is exploring all facets of a layered defense. In pursuing the technology for such defenses, the SDI seeks to:

- Capitalize on the synergism derived from repeatedly engaging enemy ballistic missiles with a mixture of weapons, enabling the progressive layers to work together to mitigate any weaknesses of the individual elements;

- Exacerbate the uncertainty of a potential attacker in his ability to succeed in his attack by presenting him with a complex defense suppression problem; and

- Deny damage from limited ballistic missile attacks and limit damage from full-scale attacks should deterrence fail.

To succeed, the SDIO must understand a broad range of technologies in order to determine their potential to perform the five basic functions of any defense. As described in the previous section, these five functions are performed repeatedly in the separate engagements of ballistic missiles in their four phases of flight (boost, post-boost, midcourse, and terminal):

- Detection of the threat and alerting the defense elements;

- Acquisition and tracking of the threat to locate it in time and space;

- Identification of the threat and discrimination against decoys to ensure efficient allocation of the defense resources;

- Interception and destruction of the threat; and

- Assessment of the results of the engagement.

To focus the SDI efforts, activities have been grouped into five program elements. These elements are designed to: (1) advance the technology base, (2) conduct experimental demonstrations that validate the technology, and (3) conduct concept and development definition efforts which focus the overall technology development on those critical issues that must be resolved to establish feasibility.

The Surveillance, Acquisition, Tracking, and Kill Assessment (SATKA) Program Element includes a mixture of some of the most and least mature technologies being developed by the SDIO. It includes technology base efforts to support surveillance, acquisition, tracking, and kill assessment that provide: (1) data on the observables from ballistic missiles and their

warheads, (2) new radar and optical sensors capable of obtaining detailed imagery of warheads and warhead deployment, and (3) on-board signal and data processing capable of performing necessary computations right at the sensor. The experiments include three general classes: boost-phase surveillance, midcourse tracking, and terminal-phase tracking and discrimination. Space-based surveillance experiments are planned for the early 1990s to demonstrate survivable means of detecting and tracking boosters from very high altitudes in space. Other space-based sensor experiments are to be conducted in the same time frame to explore our ability to track tens of thousands of objects during midcourse flight. Such platforms may ultimately include active sensors to aid in discrimination. A sensor experiment will determine the feasibility of using optical sensors to aid in target discrimination. A terminal imaging radar experiment is planned to demonstrate rapidly evolving ground-based radar capabilities.

The Directed Energy Weapons (DEW) Program Element is advancing the state-of-the-art in the technologies for: (1) high power laser and particle beam generation, (2) optics and sensors for correcting and controlling the high power beam, (3) large, lightweight mirrors and lightweight magnets for focusing the beam on the target, (4) precision acquisition, tracking, and pointing to put and hold the beam on target; and (5) fire control to capitalize on those unique features of directed energy weapons such as the ability to measure and control the energy delivered to the target. The DEW technology program includes major experiments at the subcomponent level in the four concepts currently being examined: space-based lasers, ground-based lasers, space-based particle beams, and nuclear-driven directed energy. These concepts are candidates for boost and post-boost phase intercept and for discrimination functions in the other phases. In addition, selected subcomponents for these concepts will be integrated in on-the-ground experiments designed to test interface approaches and resolve technical issues arising from the integration. The work on nuclear-driven directed energy is largely pursued by the Department of Energy and is designed to establish its technical feasibility. Equally important, the work ensures that the U.S. understands the potential impact of these emerging concepts if they were to be used against it by an adversary. It should be reiterated that emphasis in the SDI program is being given to nonnuclear weapons for defense.

The Kinetic Energy Weapons (KEW) Program Element is a collection of related research that would make use of the very high velocity of a small mass to render a ballistic missile or its warhead ineffective. The KEW program contains some of the more mature technology being investigated in the SDI. Efforts include interceptors and hypervelocity gun systems for boost-phase intercept, midcourse intercept, terminal intercept, and defense of space platforms. Both space-based and ground-based kinetic kill vehicles (KKV) are being investigated. The technology thrusts for the space-based KKV include research into a high performance multiple kill vehicle (MKV), fire control/guidance, and booster propulsion. Ground-launched interceptor studies involve both exo- and endo-atmospheric kill. Both space- and ground-based electromagnetic (EM) gun investigations are included. Space-based EM gun investigations include critical technologies such as high-g propulsion, high-g compact structures, long-range high

resolution tracking, and multiple MKV tracking. All of the experiments will be designed and conducted to conform to ABM Treaty constraints.

The Survivability, Lethality, and Key Technologies (SLKT) Program Element provides critical supporting R&T. Understanding the vulnerability of ballistic missiles to the various kill mechanisms is fundamental to assessing their effectiveness against current and responsively hardened targets. Survivability to mission completion, particularly of any defense space assets, is fundamental if defensive options are to be viable. Economical space transportation, on-orbit logistics and maintenance, kilowatt/megawatt sources of power, and multi-megajoule energy storage and conversion are potentially key needs in an affordable defense deployment.

Lethality and target hardening efforts will provide the basic theory underlying kill mechanism/target interactions, the resulting damage and response of the target to damage, and fundamental limitations in hardening countermeasures. The survivability problem includes substantial technology development, particularly in the case of space-based components. It also includes identification and assessment of innovative survivability hardware and tactics and evaluations of the survivability of conceptual designs. Space transportation, logistics, and space power efforts are designed to take advantage of existing DoD and NASA definition efforts and to expand them into the definition phase and satisfaction of the more demanding requirements of a defense-in-depth.

The Systems Concepts/Battle Management Program Element is designed to allow intelligent choices among competing approaches to defense architectures and to develop the technologies necessary to allow eventual implementation of a highly responsive, ultra reliable, survivable, endurable and cost-effective battle management/command, control, and communication (C^3) system. Threat analyses, mission analyses, conceptual design of defensive architectures and performance requirements definition, and system evaluation for all levels of a layered defense against ballistic missiles will be performed. The battle management/C^3 efforts will provide the tools, methods, and components (1) for development and eventual implementation of the system and (2) to quantify risk and cost of achieving such a system.

Innovative Science and Technology (IS&T), as the third developmental thrust (identified in Section III E), encourages the innovation of the U.S. scientific community to aid SDI research in identifying new approaches. To this end, the Strategic Defense Initiative Organization is soliciting innovative, advanced technology proposals from small businesses and the academic community.

B. STATUS AND PROGRESS

Many of the ongoing activities within the SDIO are already showing substantial progress. For example, last June, the Army Homing Overlay Experiment demonstrated the capability of a nonnuclear missile to intercept and destroy an incoming warhead outside the earth's atmosphere. Directed energy research devices are already operating at several laboratories. These include a neutral particle beam device at Los Alamos, free electron

lasers at Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and contractor facilities, and chemical and excimer laser devices at contractor facilities. A very high power chemical laser has been installed at White Sands Missile Range. It will be used later this year for lethality and vulnerability experiments. Additionally, progress is exceeding expectations in many areas, including railgun technologies as well as sensors and cryogenic refrigeration devices.

As the initial year was completed, SDIO assimilated existing programs, organized them into groupings of major efforts, and organized the start of some new activities. The FY 1986 program will complete this beginning process. The SDIO is requesting $3.722 billion for expenditures in five program elements consisting of some 73 tasks. A few examples will be cited that characterize the planned FY 1986 activities. The details of the plan are provided in Sections VII through XII.

In Surveillance, Acquisition, Tracking, and Kill Assessment technology the SDIO will:

- Begin to bring on line new capabilities for signature and background collection;
- Initiate important new technology efforts in optics and radar imaging;
- Complete the initial concept definition of several major surveillance demonstrations; and
- Continue the development of advanced architectures for high speed signal processing.

In Directed Energy Weapons technology the SDIO will:

- Continue test of critical, space compatible technologies for space-based lasers (SBL) under three major projects of the space-based laser (SBL) program--a high power hydrogen fluoride (HF) chemical laser ground experiment program called ALPHA, a precision beam sensing cleanup and control program called the large optics demonstration experiment (LODE), and a large lightweight active primary mirror demonstration experiment called the LODE advanced mirror program (LAMP);
- Begin three additional major projects--a major acquisition, tracking, and pointing program, a non-linear HF laser program, and integration experiments utilizing ALPHA/LODE/LAMP along with other hardware components;
- Continue to apply major resources in FY 1986 in advanced technologies applicable to SBL concepts in devices, beam control, large optics and acquisition, tracking, and pointing;
- Complete definition of an initial concept of a fully capable SBL to guide the SBL research efforts and initiate definition of technology development;

- Complete key experimentation of the feasibility of critical components in ground-based laser (GBL) technology;

- Continue experiments to support high brightness, high power short wavelength, excimer, and free electron lasers for the SBL concept;

- Continue basic technology development for beam control and propagation from ground transmitters;

- Initiate the development of technology for space relay mirrors;

- Establish neutral particle beam concepts feasibility through experiments using the Accelerator Test Stand;

- Continue theoretical and laboratory experiments designed to prove technologies for beam generation, control, pointing, and propagation; and

- Explore concepts for charged particle beams.

The Kinetic Energy Weapons technology program will:

- Complete initial investigations of the key technologies for the homing payload of an endoatmospheric terminal interceptor and initiate brassboard demonstrations;

- Continue validation of component technologies for exoatmospheric nonnuclear kill interceptors;

- Select hypervelocity launcher technology baselines and complete initial concept design;

- Complete in FY 1986 the initial design and assessment of the requirements on technology for an exoatmospheric reentry vehicle interceptor; define and formally approve a fundamental configuration; and

- Investigate through experimentation the feasibility of integrating guided, high-g tolerant, hit-to-kill munitions in FY 1986.

In Battle Management during this current year the SDIO is establishing baseline requirements and candidate configurations for fault-tolerant computation concepts; developing software methods and tools; developing methods for weapons release and protection against malfunctions; and generating the vast number of algorithms that will be required for a multi-layered, large-scale battle management capability. Efforts in FY 1986 will continue these investigations.

In Systems Concepts, SDIO activities are focused on the development of architectures, models, and simulations. These activities are designed to determine performance and evaluate effectiveness of the SDI technologies in all phases. In FY 1986 the SDIO will begin to evaluate technologies and designs and start detailed analyses of major issues and architectures. The new National Ground Test Facility will support this effort, when completed.

In Survivability, the SDIO is already involved in supporting the architecture and research activities associated with SDI. In FY 1986 they will increase their activity in surveying and assessing on-going work. To develop the whole technology base, projects in passive and active countermeasures work will expand appreciably as candidate concepts are selected for design. These designs could be tested in the coming years. Contracts will also be initiated to stimulate innovative ideas for enhancing systems survivability.

In Lethality and Target Hardening, the SDIO is defining and aligning the various projects in the kill mechanisms of interest--thermal kill lasers, impulse kill lasers, particle beams, kinetic energy kill, and high power microwaves. The goal is to ensure that comparable results will be available on the relative vulnerabilities of targets of interest to these kill mechanisms. In FY 1986 the SDIO will be validating effects models, bringing facilities up to where they are capable of running tests, and performing experiments of specific kill mechanisms on selected materials and structures in specific environments.

In the Nuclear Power task, the multi-organization activity investigating the SP-100 nuclear power subsystem will shift to selection and awarding of a contract to do detailed design work for test articles. The multi-megawatt project will concentrate on a final feasibility decision and the awarding of follow-on studies for approximately six concepts.

In Space Logistics, investigations will concentrate on completion of the examination of both immediate and longer term goals for promising technology to reduce costs significantly.

SECTION VII

SURVEILLANCE, ACQUISITION, TRACKING AND KILL ASSESSMENT (P.E. 63220C)

This program involves research into sensing of information for (1) initiation of the defense engagement and (2) battle management and assessment of the status of forces before and during a defense engagement. The program includes 11 projects and 20 tasks.

A. PROJECT: 0001 - Radar Discrimination Technology and Data Base

	FY 1984	FY 1985	FY 1986	FY 1987
Radar Discrimination Technology and Data Base	24.10	29.90	74.10	98.46
COBRA JUDY		17.10	14.40	31.31
PBV Data Collection		2.70	46.30	53.03
Discrimination Dev & Radar Tech		10.10	13.40	14.12

1. Project Description: This project is composed of three tasks. It is designed to provide radar facilities, measurement equipment, and test targets for the collection of signatures of ICBM components and reentry vehicles, and supports collection and interpretation of the data. The three tasks are:

COBRA JUDY: The COBRA JUDY radar is currently operational and is collecting data.

Post-Boost Vehicle (PBV) Data Collection: An instrumentation radar capable of acquiring data will be developed, fabricated, installed, and operated in this task.

Discrimination Development and Radar Technology: This task will develop and evaluate radar discrimination techniques and will develop advanced radar and signal processing technologies. The primary emphasis in discrimination will be development of techniques. The radar technology effort will advance transmitter and receiver performance and develop advanced phase shifters required by large antennas. Data collected by COBRA JUDY, the PBV Data Collection effort, and other radars will be used to support this task.

2. Program Accomplishments and Plans: Additional automated mission capability was achieved, data collection systems were expanded, and new radar development was initiated in FY 1984.

Data reduction capability is to be completed in FY 1985. Radar fabrication and modification is being completed, and bandwidth is being increased. A radar is being made operational, and a radiometer is being completed. Data collection and processing efforts will accelerate as these capabilities become operational.

In FY 1986, expanded bandwidth operation will begin; data collection, processing, and analysis will continue; and developments will be expanded. The collected data will be used to provide the basis for algorithm development. Future efforts include operation of these data collection capabilities. Data processing and analysis facilities will require monitoring of collections systems. New analysis techniques will be pursued as they are developed, and better methods of utilizing and interpreting data will be examined.

B. PROJECT: 0002 - Optical Discrimination Technology and Data Base

	FY 1984	FY 1985	FY 1986	FY 1987
Optical Discrimination Tech and Data Base	50.50	133.70	198.70	192.31
IR Exo/High Endo Signature Data		95.60	113.80	115.91
Laser Image Data		3.20	28.90	30.85
IR Background Studies		34.90	56.00	45.55

1. Project Description: This project consists of three tasks. They are designed to provide optical facilities, measurement equipment and some test targets for collection of signatures of ballistic missile components and reentry vehicles. The project is also designed to support collection and interpretation of the data. The three tasks are:

Infrared (IR) Exoatmospheric and High Endoatmospheric Signature Data: A data base is necessary in order to design and evaluate optical system sensors. This task provides sensors and platforms to acquire and update this data, the missions to perform the collection, and the subsequent data reduction and analyses.

Laser Image Data: This task will develop a data base on laser imaging. The effort develops a near-term hardware technology base and subsequently collects a data base of measurements taken by an imaging system. Laboratory measurements will precede extensive field tests and eventual collection of data.

Infrared Background Studies: Accurate prediction of IR backgrounds and their effect on target signatures is needed to understand IR sensor performance. This task will develop models and computer codes to predict the spectral, spatial, temporal, and brightness characteristics of the natural background. The background studies will investigate IR emission and absorption under a range of conditions. Data will be collected using field systems and in the laboratory to support model development.

2. Program Accomplishments and Plans: Analysis of data from two major auroral measurement experiments was initiated in FY 1984. These experiments are called Earth Limb Infrared Atomic Structure (ELIAS) and the Field Widened Interferometer (FWI) provided data. Rocketborne hardware development and design were completed, and preliminary flight tests without the sensor were begun. Aircraft support facilities were completed.

In FY 1985, experiments are acquiring the first data and making comprehensive measurements. This information on natural variability and auroral excitation will support modeling. Additional flights are being launched to complete a data base, and a reflight in daylight conditions is being scheduled.

Development will continue in FY 1986, and an engineering test will be conducted. Development of a laboratory simulator to verify sensor performance will be initiated.

C. PROJECT: 0003 - Imaging Radar Technology

	FY 1984	FY 1985	FY 1986	FY 1987
Imaging Radar Technology	6.30	15.30	45.80	122.96
Large Array Technology		9.40	27.80	66.46
Near-Term Imaging Demonstration		5.90	8.00	4.64
Satellite/Aircraft Imaging Radar			10.00	51.86

1. Project Description: This project is comprised of three tasks. It is designed to pursue the requisite technology for demonstrating radar imaging in real-time in order to discriminate among reentry vehicles, decoys, and other components of ICBM systems. Radars can provide cross-section history, precision metrics to monitor kinematics, and coherent range, cross-range images. During midcourse, further discriminations may be possible through radar observations and measurements of characteristic signatures. Radars may also be valuable for discrimination of reenty vehicles from sophisticated decoys just prior to and during reentry.

Large Array Technology: This task is directed toward the development and demonstration of key technologies for large phased-array imaging radars. Development of various radar items will be a major portion of the task.

Near-Term Imaging Demonstration: This task provides the hardware and software necessary to implement and demonstrate high frequency radar systems. Initially, sufficient hardware and software will be developed and implemented in a simulation facility. This simulation will be capable of playing back data recorded by other sources. After successful demonstration of the imaging capability in the simulation facility, the hardware and software will be expanded so that operational measurements can be made at an existing radar facility.

Satellite and Aircraft Imaging Radar: Under this task, technologies developed under other tasks, principally Imaging Algorithm Development, Large Radar Array Technology, and Real-Time Signal Processing, will be integrated with consideration given to various radars for demonstration of this concept.

2. Program Accomplishments and Plans: In FY 1984, the antenna concept was defined considering factors such as weight, storability, on-orbit deployment, module cost and weight, and ease of fabrication. In FY 1985,

antenna material is being selected. Test samples of moderate sizes are being built, and structural/electrical and thermal/vacuum tests are being conducted. Demonstrations are also being performed.

Testing efforts will continue in FY 1986, and a technology base program to develop advanced items will be initiated.

D. PROJECT: 0004 - Imaging Laser Technology (Optical)

	FY 1984	FY 1985	FY 1986	FY 1987
Imaging Laser Technology (Optical)	5.60	28.30	127.00*	188.75
Large Optics Technology		8.40	23.00	22.27
Laser Imaging Technology		10.90	71.00	99.96
Imaging Laser Measurements		9.00	28.00	38.80
Early Demonstration of Angle-Only Tracking			5.00	27.72

1. Project Description: This project is comprised of four tasks. It is designed to perform research on concepts of future electro-optical imaging capabilities. The four tasks include:

Large Optics Technology: A comprehensive program of technology development is required to make possible the wide variety of large optics required in some concepts. Technology must be developed and demonstrated that allows production of very large, very lightweight, and very precise optics. Such optics will have to operate at cryogenic temperatures and have the ability to reject stray radiation even when the source is very close to the target. The optics must be manufactured at a high rate to allow deployment of a constellation in a timely manner. This task is divided into five principal subtasks: precision polishing, active/segmented mirrors, off-axis rejection, rapid fabrication, and metal mirrors.

Laser Imaging Technology: This task will develop technologies required for the construction of components of laser transmitters and receivers. A vigorous program will be undertaken to confirm technical feasibility. Emphasis will be placed on discrimination. Potential countermeasures will be identified and their effectiveness addressed. This task will be supported by, and proceed in parallel with, the Imaging Laser Measurements task.

Imaging Laser Measurements: A continuing program of measurements and demonstrations must accompany the Laser Imaging Technology task development. The objectives include verification of sensor concepts and parameters assumed in initial design studies and acquisition of optical data. Data will be gathered through the use of existing material measurement capabilities, ground test chambers, and new flight-test platforms.

Early Demonstration of Angle-Only Track: This task will provide data and explore issues related to midcourse acquisition, tracking, discrimination, and designation. Alternative approaches are being considered for this task which is still in its infancy.

2. Program Accomplishments and Plans: An initial effort in this project in FY 1984 was development of ultra-lightweight optics and assessment of procedures to produce them. Promising computer-controlled polishing techniques were investigated to scale-up machines capable of working large surfaces. Stable laser oscillator studies were performed leading to several possible constructions, and different techniques were investigated.

Starting in FY 1985, this project draws on and continues existing technology base activities. A small number (two to four) of rapid optics fabrication efforts are being selected for demonstration at medium scale. Work is being initiated to develop appropriate algorithms for this work.

Rapid optics fabrication efforts will be focused in FY 1986 into a demonstration at medium scale. The project will integrate fundamental technologies and conduct subsystem demonstrations required to make technical feasibility decisions. Initial parallel efforts will result in down-selection to engineering development of the one or two most promising approaches, and the measurements program will verify sensor design parameters.

E. PROJECT: 0005 - IR Sensor Technology

	FY 1984	FY 1985	FY 1986	FY 1987
IR Sensor Technology	86.80	57.80	151.40	157.83
Optics Technology		16.90	54.40	55.01
IR Focal Plane Development		20.40	64.00	66.70
Space Cryocoolers		20.50	33.00	36.12

1. Project Description: This project is made up of three tasks. Under it there will be research on the technologies associated with advanced IR focal planes for various surveillance, acquisition, tracking, and kill assessment systems. The primary emphasis is directed toward passive IR systems; however, a number of technologies are generic and will support other areas as well. The tasks will develop all critical technologies to support the design and development of high performance optical sensors, detector materials, associated electronics and integrated focal planes, and high efficiency, long-life cryogenic refrigeration systems.

Optics Technology: This task will establish the critical technologies needed to design and develop high performance optical sensors. Key efforts include: development of technology for wide field-of-view optical systems; development of large, high-quality, passive optical sensors; conceptual design of high-performance optical sensors; development of large arrays of nuclear-hardened detectors; development of signal processing algorithms and hardware to support the large detector arrays; development of sensor calibration and test facilities; and development of techniques to allow production of these components in quantity.

IR Focal Plane Development: Development of detector and multiplexer materials for integration into IR focal planes having large array size will be accomplished in this task. The work is being performed in two

broad classes of detectors. The task will also develop electronics required to interface with these arrays and the pilot production processes needed for manufacturing large quantities of these items.

Space Cryocoolers: The objective of this task is to develop long-lifetime, high-efficiency, spaceborne cryogenic refrigeration systems. The task is divided into two segments. One is continuing and extending existing cryocooler technologies. This effort will consider several approaches offering increased efficiency, lower-operating temperatures and longer lifetimes. The second subtask considers new concepts, such as magnetic ordering and disordering for coolers with higher efficiencies.

2. Program Accomplishments and Plans: Some elements for IR sensors were tested in FY 1984 under operational conditions. Others were tested to determine vulnerability and survivability. Signal processing techniques were demonstrated. The surveillance and tracking system focal plane technology program was continued with competitive awards of the system program and the focal plane technology program. Contracts were augmented for focal plane development and for material development. Development efforts were augmented and test facility upgrades begun. Candidate machines entered performance/life testing.

A one-of-a-kind facility is being used to evaluate the state-of-the-art devices, and advanced concepts are being vigorously pursued. Development of a simulator-based evaluation testbed to measure the performance of new sensor architectures is being initiated. Increased efforts are being conducted to accelerate the development of longer lived, flight-capable refrigerators to support SDI requirements. Efforts on detector arrays and their associated cryocoolers will be continued in FY 1986.

F. PROJECT: 0006 - Boost Surveillance and Tracking System (BSTS) Experiment

	FY 1984	FY 1985	FY 1986	FY 1987
Boost Surveillance and Tracking System Experiment	28.30	38.00	131.10	302.91

1. Project Description: This project pursues the technical research necessary for a near real-time, fully responsive experiment. The program includes system concept definition efforts and development/validation of critical sensor and data processing components associated with these concepts. The capability to satisfy additional missions will also be evaluated. This project is designed to satisfy SDI requirements as well as the needs specified in the Office of the Secretary of Defense Master Plan for Ballistic Missile Tactical Warning/Attack Assessment provided to Congress in 1981.

2. Program Accomplishments and Plans: Four concept definition efforts were started in FY 1984 to develop competitive approaches for survivable, endurable, and cost-effective experiment options. These efforts will provide a range of specific system designs; technology assessment and development planning; system transition plans; and life-cycle cost estimates for all options. In parallel, technology risk reduction efforts are underway.

The FY 1985 effort is concentrating on developing, assessing, and selecting the appropriate concept for experimental verification. The concept definition efforts are designing subsystems. The experiment definition efforts are being completed and evaluated. Further risk reduction efforts are being conducted. A concept selection decision is being conducted to review technical approaches and to start demonstration and development of the experimental system.

In FY 1986 a preliminary concept selection decision will be made, an experimental demonstration program will be initiated, and further risk reduction efforts will be conducted.

G. PROJECT: 0007 - Space Surveillance and Tracking System (SSTS) Experiment

	FY 1984	FY 1985	FY 1986	FY 1987
Space Surveillance and Tracking System Experiment	35.60	37.00	136.00	267.13

1. Project Description: This project pursues research in space surveillance. These research efforts are specifically oriented toward the requisite technology. The primary activity in this project is concept definition and preliminary research.

2. Program Accomplishments and Plans: Three concept definition efforts were started in FY 1984 to develop competitive approaches for survivable, endurable and cost-effective experiment options. These efforts will provide: a range of specific system designs; technology assessment planning; system transition plans; and life-cycle cost estimates for all designs. In parallel, technology risk reduction efforts are underway.

Fiscal year 1985 efforts are concentrating on developing, assessing, and selecting an appropriate concept for this experiment. These concept efforts are defining the midcourse surveillance and tracking system experiment. Further risk reduction efforts are being conducted. A concept selection decision is being conducted to review system technical approaches and to start demonstration of a survivable space surveillance and tracking system experiment.

A preliminary concept selection decision will be made in FY 1986, and an experimental demonstration program will be initiated on a survivable midcourse surveillance and tracking system. Further risk reduction efforts will be conducted. The utility study of the alternate/advanced concepts, associated technology requirements, and potential technology issue resolution programs will be completed.

H. PROJECT: 0008 - Optical Surveillance Experiment

	FY 1984	FY 1985	FY 1986	FY 1987
Optical Surveillance Experiment	28.80	117.00	191.64	167.98

1. Project Description: Research for this project will investigate the feasibility of an optical sensor system. An experimental device will be tested under this project to demonstrate the technical feasibility of using optical sensors on an airborne platform.

2. Program Accomplishments and Plans: A request for proposals was prepared and issued in FY 1984. An experimental demonstration contract was awarded. Requirements were determined and apportioned to subsystems, and the design of those subsystems was initiated.

In FY 1985, experiment and subsystem design are being completed and fabrication begun. Integration, test, and evaluation plans are being completed, and target support equipment specifications are being initiated.

In FY 1986, the experiment will be analyzed for design feasibility, requirements traceability, and interface definition and specification. Subsystem design trades and subassembly performance analysis will be performed to finalize drawings for the experimental program.

I. PROJECT: 0009 - Terminal Imaging Radar Experiment

	FY 1984	FY 1985	FY 1986	FY 1987
Terminal Imaging Radar Experiment	100.50	6.00	74.60	93.00

1. Project Description: The objective of this project is to develop a fixed ground-based track and imaging radar.

2. Program Accomplishments and Plans: In FY 1985, critical subsystems and components were tested.

Competitive Concept Definition Studies will be completed in FY 1986 with contractors delivering their proposed radar specification and software requirements. Two of the contractors will be selected to continue detailed design to assure that the selected design is in accordance with the end-item specification. Fabrication and integration will be performed. Acceptance tests will be conducted at the contractor's facility, and installation will be performed.

J. PROJECT: 0010 - Space-Based Imaging Experiment

	FY 1984	FY 1985	FY 1986	FY 1987
Space-Based Imaging Experiment			5.80	11.09

1. Project Description: This project pursues the research for a space-based imaging experiment. Although the gathering of data to permit assessment will reside in other SATKA projects, this project will compare the efficiency of various approaches. Each approach has peculiar attributes and each requires advances in technology. The best choice will not be evident without further research.

2. Program Accomplishments and Plans: Concept definition efforts will be initiated to develop a survivable, enduring, and cost-effective system experiment. This effort will provide a range of specific options, technology assessment and development planning, transition plans, and life-cycle cost estimates. The FY 1986 effort will concentrate on assessing and selecting the appropriate imaging sensor for the experiment.

K. PROJECT: 0011 - Common Technology and Architecture

	FY 1984	FY 1985	FY 1986	FY 1987
Common Technology and Architecture		82.95	250.20	272.50
SATKA Systems Studies		17.15	49.00	43.70
Imaging Algorithm Development		3.00	9.50	14.71
Radiation Hardened Circuits		33.40	99.80	114.89
Real-Time Signal Processing		29.40	91.90	99.20

1. Project Description: This project is designed to develop technologies common to surveillance,acquisition, tracking, and kill assessment (SATKA). The project tasks include the development of imaging algorithms, the achievement of radiation-hardened circuits and implementation of real-time signal and data processing techniques. The project also includes a studies task that addresses trade-offs and utility of the various sensor designs under consideration.

SATKA Systems Studies: The objective of this task is to define, perform, and update systems level analyses in support of other SATKA tasks. The efforts accomplished in these analyses will: examine alternate sensors in light of evolving technologies, improved understanding of underlying phenomenology, and maturing perception of costs and cost trade-offs; examine the impact of survivability on the choice of sensor components; and assess the interface required between various sensors and between the sensors and other elements of the overall defense.

Imaging Algorithm Development: Current techniques for imaging potential targets depend upon human intervention to provide the best estimates of target motions. This task will develop and demonstrate algorithms that will assess target motion and form images based upon these initial assessments. The algorithm development will provide data necessary to judge the relative efficiency of each system type. The task is further broken down into four subtasks: (1) Concept Exploration, (2) Algorithm Coding, (3) Simulation Development, and (4) Simulation.

Radiation-Hardened Circuits: To accomplish various mission objectives during hostilities, key performance elements must survive in the presence of high levels of nuclear radiation. Particularly, electronic circuits and memories must be developed to very high levels of hardening. This project will establish needed technology. Initial efforts will focus on materials technology and manufacturing processes. Later phases will include brassboard demonstrations and technology insertion efforts.

Real-Time Signal Processors: This task will develop processing systems capable of supporting the sensors developed in other tasks.

Emphasis will be on systems that can meet requirements, operate autonomously, be fault-tolerant, and be capable of system reconfiguration. A technology program has been defined that will generate a technical base, perform research leading to fault-tolerant architectures, and develop of advanced algorithms for high-speed data processing. Early thrusts will be completion of an advanced on-board signal processor, an advanced distributed on-board processor, and a dynamically reconfigurable processor.

2. Program Accomplishments and Plans: Work on technology continued in FY 1984.

An effort to obtain a family of computer chips is near the test and evaluation stage. Pilot lines will be added in FY 1985 for some devices, and some reliability and radiation testing will be performed. Development of a simulator-based evaluation test bed to measure the performance of new sensor architectures is being initiated.

Fiscal year 1986 work continues the basic developments initiated earlier. During FY 1986, work will begin on specific areas to demonstrate technology needed for specific SDI applications. Algorithms for high-speed signal processing will be completed and demonstrated. The development of advanced computing architectures which support experimental demonstration programs and technology base efforts to meet advanced SDI requirements will continue.

SECTION VIII

DIRECTED ENERGY WEAPONS TECHNOLOGY (P.E. 63221C)

This program provides development and demonstration of technology required for directed energy weapon concepts for boost and post-boost phase intercept for defense against ballistic missiles. The program includes 4 projects and 28 tasks.

A. PROJECT: 001 - Space-Based Laser (SBL) Concepts

	FY 1984	FY 1985	FY 1986	FY 1987
Space-Based Laser Concepts	157.00	162.70	371.90	507.70
Devices		5.52	18.00	41.10
Beam Control		4.10	18.30	34.30
Large Optics		4.40	11.10	21.20
ATP Technology		8.18	37.10	69.10
Major Experiments		120.40	179.80	234.00
Space ATP Support			80.00	80.00
Concept & Development Definition		7.00	20.60	28.00
Innovative Science and Technology		4.80	7.00	TBD
Other Technology		8.30	-	-

1. Project Description: This project and its nine tasks contain the redirected technology development activities of the Space Laser Program originally described to Congress in the 1982 "DoD Space Laser Program Plan." It is designed to demonstrate the feasibility of the major subsystems of a space-based chemical laser to engage ballistic missiles. In addition, it pursues technologies to provide the performance growth required in an evolving offense-defense interaction. The primary candidate for achieving these performance levels is a concept that allows fabrication and deployment of systems capable of defeating threats of interest and growth in performance to meet a threat hardened to directed energy weapon (DEW) radiation. Additional longer term device concepts, such as short wavelength chemical and free electron laser candidates suitable for space-basing, are also under investigation. As the technology matures, initial capabilities in other strategic defense mission areas (antiaircraft and antisatellite) can be spun-off into other development activities if such applications prove to be cost-effective.

SBL Technology Development tasks included in this program are designed to: (1) establish component technologies required for performance growth of space-based laser deployments, and (2) maximize the yield of technology outcomes not only for the SBL thrust but also for the other thrusts of the Strategic Defense Initiative (SDI). These tasks include:

- Laser Device Technologies which explore enhanced chemical laser performance, short wavelength chemical lasers, etc;

- Beam Control Technologies which explore telescopes, advanced sensors and processing techniques for beam clean up; alignment systems for high power beams, etc;

- Large Optics Technologies which explore optical components and coatings; fabrication technology; large space mirrors and the technology to rapidly fabricate them, etc.; and

- Acquisition, Tracking, and Pointing (ATP) and Fire Control Technologies which explore advanced ATP components, advanced fire control sensor techniques, large structure technology, etc.

Not included in this project are the basic technologies for free electron lasers, also a candidate for space-basing, which are under investigation in project #002, Ground-Based Lasers.

Major Experiments include a series of experiments on the key technologies ultimately needed for an operational weapon—the laser device or beam generator (ALPHA), beam control (Large Optics Demonstration Experiment - LODE), and large optics (Lode Advanced Mirror Program - LAMP), and a newly constituted acquisition, tracking, and pointing demonstration program designed to replace Talon Gold. LODE and LAMP also support the other directed energy projects in this program element by providing the major part of the generic technology needed for those concepts. The objective of the ALPHA program is to develop the technology for chemical lasers which, in a configuration designed for space operation, can generate near diffraction-limited beams with high efficiency. The LODE and LAMP will demonstrate critical beam control and optics technology. The newly constituted acquisition, tracking, and pointing demonstration program will concentrate on a series of experiments that will demonstrate, with increasing degrees of difficulty, all elements and technologies required for space- and ground-based lasers as well as kinetic energy weapons and space-based surveillance. The mutual interactions of the various components of a high energy laser weapon system will be investigated under the high power integration technology project. In the first phase, generic experiments will investigate interactions utilizing the chemical laser at White Sands Missile Range. In a later phase, another generic chemical laser integration experiment is planned utilizing technologies of the type being developed for space-based chemical lasers (e.g., ALPHA & LODE/LAMP hardware).

Space ATP Support funds the interface equipment and the common payload orientation system and mechanical interfaces to be used in planned space experiments. These experiments are designed to: collect background and target signature data at multiple wavelengths; assess designation capabilities; and perform precision acquisition, tracking, and pointing tests.

Concept and Development Definition (CDD) supports the entire project by defining the technology development and demonstration plans to resolve critical DEW issues. To achieve this, three interrelated CDD tasks will be pursued: (1) concept definition for technology identification -

synthesize and evaluate concepts, allocate performance and provide requirements flowdown, perform supporting trade studies and technology assessment and planning, (2) demonstration definition - define, price, and schedule the ground and space demonstrations to validate critical technologies, and (3) operational weapon concept definition - provide the conceptual design of an operational system as a source of additional technology guidance and as a common base for interaction with the System Architecture Studies.

2. Program Accomplishments and Plans: Major subsystem experiments are emerging. The broad technology base development activity under this project provides technologies that benefit other directed energy weapons programs.

SBL Technology Development efforts in FY 1984 were a mix of continuation of activities established in the early 1980s, some existing programs reoriented to SDI needs, and some new efforts. Device Technology efforts included continued pursuit of high efficiency nozzle designs, investigation of large optics fabrication techniques and associated metrology instruments, and the identification and formulation of plans for promising new short wavelength chemical lasers. Beam Control efforts continued development of high performance sensors. Large Optics efforts completed the carbon-carbon materials program and demonstration of the applicability of carbon-carbon technology to large space optics. Efforts to develop mirror coatings for silicon mirrors continued. Acquisition, Tracking, and Pointing efforts included initiating development of a retargeting simulator, selecting a real-time laser damage assessment concept and continuing the ATP issues investigation. Major Experiment activities continue to be focused on a demonstration of the critical elements of SBL weapon technology. The ALPHA program has completed its initiation activities and modifications to the test facility. In the LODE Advanced Mirror Program (LAMP), design activities were concluded. The LODE program continued design activities focused on meeting the beam control requirements. The Talon Gold program, after considerable high level review, was placed on hold pending a detailed review of acquisition, tracking, and pointing requirements for the entire Strategic Defense Initiative. Components of the generic integration experiment continued to be investigated throughout FY 1984. Modifications to the chemical laser at White Sands Missile Range were in progress. In Concept and Development Definition, efforts begun under the 1982 Space Laser Program Plan to develop a concept for a multi-mission SBL deployment were completed. For Phase II of the effort (to begin in FY 1985) the contractors were instructed to focus on concepts for the weapon platform only and to examine concepts for the requirement of SBLs for use in defense against ballistic missiles only.

FY 1985 Technology Development efforts in Device Technology are investigating potential means of scaling to high brightness levels. These efforts continue enhancement of the performance of chemical laser nozzle concepts with the goal of increasing the efficiency of laser energy extracted per gram of reactant used. In Beam Control, investigation of concepts for rapid retargeting of high-power beams are being accelerated. Development of technologies for sensors and beam-sampling concepts such as holographic grating elements is continuing. Also in 1985, conceptual definition of a mirror system is being completed. In Large Optics, the development of advanced technologies and materials is beginning. The development

and test of advanced cooling concepts for mirrors under very high radiation loads is continuing. Acquisition, tracking, and pointing technology efforts are being initiated for the rapid retargeting simulator along with complementary efforts in the area of advanced digital control techniques.

FY 1985 activities in the Major Experiments area include the ALPHA I chemical laser gain generator, the facility, and the full-scale optics demonstration unit (FSDU). The large optics demonstration experiments are continued, as is the advanced mirror program. The Large Optics Diamond Turning Machine (LODTM) program is beginning fabrication, testing, and installation of metrology instrumentation. Concept and Development Definition (CDD) activities in FY 1985 are developing weapon platform concepts with the purpose of identifying the technology content of the weapon segment and its interfaces with other major system segments in a space-based laser deployment for defense against ballistic missiles. Also in FY 1985, CDD is defining the statement of work for efforts expected to begin in FY 1986 that will define concepts for later demonstrations.

In FY 1986 device technology efforts will complete the concept definition for an advanced infrared (IR) chemical laser. Free electron laser (FEL) and short wavelength laser technology development continues. Beam control efforts continue work on concepts for rapid retargeting, innovative wavefront sensors, and high-power, aperture-sharing components. Large optics technology efforts include: a high-quality demonstration segment; precision polishing and metrology of large mirrors for space-based laser performance requirements; Zerodur fabrication processes; advanced cooled mirrors; and high-power hydrogen fluoride (HF) coatings for space-based laser optics. Acquisition, Tracking, and Pointing efforts include brassboard experiments and analysis activities. Work on the rapid retargeting simulator will continue. Major Experiments: Experiments designed to explore the mutual interaction of components of a high energy laser weapon system will be conducted. The design of the hydrogen fluoride (HF) integration experiment will be completed. Concept and Development Definition activities will complete the technology identification effort and initiate definition of the required demonstrations.

In the fiscal years beyond FY 1986, the Device Technology effort will continue to investigate free electron laser (FEL) and short wavelength chemical laser technology as candidates for space-based laser concepts. High efficiency nozzle designs will be evaluated to select the most promising concept. This concept will be fabricated and tested in a high power device. Beam Control activities will complete concept definition studies for beam control and tracking; will demonstrate wavefront control; will complete an innovative wavefront sensor and a high-power, aperture-sharing component; and will perform experiments with agile pointing sensors. Performance models and experimental data bases will be available by the end of the decade. Large Optics Techniques for improved numerically-controlled surfacing and advanced process control metrology will be developed and employed to produce a segment of a large primary mirror. Brassboard testing of this segment will validate large optics performance. Experiments with a high actuator density mirror will be completed. Advanced materials and processing steps for improved substrates for a high actuator density test

article will be validated. Advanced materials and technologies for high-power mirrors to satisfy requirements for a space-based laser will be explored. Representative mirrors will be fabricated and their thermal distortion performance fully validated. Deposition processes and materials for high-reflectance coatings for space-based chemical lasers will be investigated. The most promising option will be selected and used to coat the advanced mirrors. Coating performance will be validated. Large optical structures will demonstrate the required structural control tolerances. Innovative approaches for chemical laser devices will be assessed and subsequent experiments planned. Acquisition, tracking, and pointing technology efforts will continue. Advanced sensor hardware for active tracking and inertial reference will be developed. Fire Control technologies will be advanced. Major Experiments: The ALPHA HF chemical laser device feasibility will be established. The LODE Advanced Mirror Program (LAMP) and Large Optics Demonstration Experiment (LODE) beam control technology demonstrations will be completed. Testing of the mutual interactions of the various high-power components will be completed. Concept and Development Definition will complete the weapon platform definition by providing an operational system concept to support a program review. Also, to support this review, design concepts for advanced demonstrations will be available.

B. PROJECT: 0002 - Ground-Based Laser (GBL) Concepts

	FY 1984	FY 1985	FY 1986	FY 1987
Ground-Based Laser Concepts	133.10	178.15	431.54	455.20
Laser Devices		82.05	110.60	95.00
Ground Segment Beam Control		66.12	99.00	103.00
Space Segment		2.00	32.00	67.00
Major Experiments		4.13	149.24	150.00
Concept & Development Definition		5.00	19.70	25.20
Innovative Science and Technology		5.20	10.50	TBD
Other Technology		13.65	10.50	15.00

1. Project Description: The seven tasks of this project provide the technology base, demonstrations, and designs required to provide a firm basis for deciding whether or not to pursue a ground-based laser weapon for boost-phase intercept. This project will establish and demonstrate the major subsystems for this ground-based laser concept at visible/ultraviolet (V/UV) wavelengths. There are three main thrusts: Technology Development, Major Experiments, and Concept and Development Definition.

Technology Development contains the first three tasks—major device efforts (excimer and free electron lasers), ground segment telescope development, and space segment relay mirror definition and development along with associated visible/ultraviolet optics technology development. The project shares developments in components, large optics, beam control, and acquisition, tracking, and pointing technology with the space-based laser project. Investigations of free electron laser (FEL) technology for use as a space-based, short wavelength laser are included here with the other FEL tasks rather than in the space laser project. Finally, the project provides the resources necessary to investigate new and innovative

concepts that promise major increases in short wavelength subsystem performance.

Excimer laser devices operate at wavelengths in the near-ultraviolet region of the spectrum. They are likely to be limited by size, weight, and efficiency considerations to being ground-based systems. There are two device candidates being pursued in this excimer program.

Free electron lasers (FEL) operate by interacting high energy electron beams with magnetic "wiggler" fields to convert the kinetic energy of the electron beam into optical radiation. By recovering the unexpended energy of the electron beam, high laser efficiencies may be possible. Because of their wavelength selectability and relatively high electrical efficiency, FEL devices are promising candidates for both ground- and space-based platforms. This project will establish the feasibility of scaling to the required power levels with good beam quality and high electrical efficiency.

In the ground segment technology development efforts, Beam Control and acquisition, tracking, and pointing technology will be pursued. This segment of the ground-based laser system must correct for the optical aberations in the beam.

Space segment technology development efforts include concepts for the relay mirrors which reflect the beam transmitted from the ground station and the mission mirrors which receive the relay of the beam and focus the beam on the target. Surfaces of mirrors must be figured (shaped to) within a small fraction of a wavelength. The rapid retargeting times needed require new concepts. Mirror coating techniques must maintain ultraviolet (UV) quality over a wide variety of incidence angles. All mirrors require mirror figure control to a fraction of a wavelength. The most stressing acquisition, tracking, and pointing requirement for all potential directed energy weapon systems are associated with the low earth orbit mission mirror. The target must be accurately tracked, inertial motion sensed, and the beam positioned. Cooperative tracking to the other (relay mirror) components of the system must also be maintained to this level. Aperture sharing techniques must be developed.

Major Experiments are planned which integrate related elements of the technology development into major demonstrations of device, ground segment, and space segment technology. Excimer and FEL devices will be demonstrated and integrated with a beam director.

Concept and Development Definition supports the entire project by defining the technology development and demonstration plans to resolve critical DEW issues on a scale that establishes technical feasibility of realizing weapon-level performance. To achieve this, three interrelated CDD tasks will be pursued: (1) concept definition for technology identification —concept synthesis and evaluation, performance allocation and requirements flowdown, supporting trade studies and technology assessment and planning, (2) demonstration definition—define, price and schedule the ground and space demonstrations to validate critical technologies, and (3) operational weapon concept definition—provide the conceptual design of an operational

system as a source of additional technology guidance and a common base for inputs needed in the System Architecture Studies.

2. Program Accomplishments and Plans: Building on (1) prior technology efforts in short wavelength beam generators, (2) a potential to improve beam quality and beam power, and (3) initial successes in beam control, the ground-based laser program is moving toward major decision milestones designed to demonstrate readiness to proceed.

In Technology Development, excimer laser technology development passed important milestones in FY 1984. Demonstrations of the critical components continued to be expanded. Source selection was initiated and completed for one concept. Plans for the other were nearing completion but were placed on hold due to funding limitations and a pending redefinition of the approach. Component experiments continued, yielding progressively improving outputs and efficiencies. The technology development efforts for radio frequency linear accelerator driven, free electron lasers were continued. A preliminary program to establish the feasibility of using induction linear accelerators, such as the Advanced Test Accelerator (currently being built under a non-SDI program) for high power, free electron lasers was defined. Initial experiments conducted on the Advanced Test Accelerator have shown promise. In the ground segment activities, experiments that predate the SDI were continued. Technology efforts were initiated to build the necessary adaptive optics and wavefront sensors. Computer simulation of relay systems has shown development paths for the most significant performance payoffs. Inertial elements for stabilization have been demonstrated.

In FY 1985, the major thrusts of the ground-based laser activities (1) continue preparations for major demonstrations and (2) initiate the new activities described in the approved plan.

Technology Development: The excimer laser program in FY 1985 is completing experiments in xenon fluoride (XeF) lasers with Raman beam quality improvement. Critical technology experiments are being completed and hardware experiments have begun. An upgrade of the electron beam quality of the Advanced Test Accelerator is being undertaken and free electron laser experiments are being conducted. Experiments designed to demonstrate electron beam energy recovery in a free electron laser are underway and resonators for high power FELs are being tested. Key beam control experiments are being completed. Evaluation of adaptive optics components are also being completed. Efforts will begin on technology developments for advanced adaptive optics. In large optics, a preliminary look at space relay mirrors is being initiated to verify the relevance of planned technology development. Acquisition, tracking, and pointing and inertial sensing technology tasks are being initiated.

In Major Experiments, design activities are being initiated to define the proper experiment to resolve the remaining physics issues.

Concept and Development Definition will be initiated late in FY 1985 with a multiple contractor concept definition of a ground-based laser boost-phase intercept system designed to identify technology needs and ensure the relevance of the technology development program.

In FY 1986, a major thrust will be the excimer laser demonstrations. Source selection activities for the second device type will be initiated early in the year. Prior to selection, all of the technology components will have been tested. The free electron laser program will continue to investigate high gain FEL operation on the Advanced Test Accelerator. Experiments to support scaling to shorter wavelength FELs will be completed. The design of a free electron laser test bed using either a radio frequency or induction linear accelerator will be based on these experiments. Issues of the associated beam control for both the FEL and excimer laser will be addressed. Space segment technology efforts will continue to focus on concepts and components. Advanced technology for space segment systems will investigate beam transfer through relay systems, and innovative tracking systems. Technology demonstrations to support the ground and spaceborne experiments are scheduled. Work on adaptive optic components will continue. Concept and Development Definition activities will initiate the design/definition. Concept definition for technology identification will be completed in FY 1986.

In the years beyond FY 1986, Technology Development activities will continue to experiment with free electron laser designs. Parallel to these experiments additional technology development will support the efforts. Technology development activities in excimer lasers and the ground segment will continue until feasibility is established. Optical component technology development will ensure the necessary optics subsystems are available for use in all the other efforts. Innovative concepts for ground segment beam control will be investigated. The development of the space segment will proceed to proof-of-principle.

Design efforts for optical segments will be started and multiple mirror segments will be delivered for use in subsystem experiments. Wavefront sensing and control technology will concentrate on high bandwidth/high precision measurement techniques. Low noise, control moment gyro technology will be addressed in joint retargeting experiments with the space-based laser effort. The acquisition, tracking, and pointing effort will begin the fabrication of a test facility to support key experiments in critical functional areas.

Major Experiments will continue the development of the excimer laser. Accompanying the device development, ground segment experiments will continue.

Concept and Development Definition activities will parallel the technology development efforts providing them with the technology development and definition plans to guide these efforts. Three interrelated efforts are planned: (1) concept definition for technology identification, (2) system level definition, and (3) operational weapons concepts definition.

C. PROJECT: 0003 - Space-Based Particle Beam (SBPB) Concepts

	FY 1984	FY 1985	FY 1986	FY 1987
Space-Based Particle Beam Concepts	13.90	32.15	133.40	184.00
Neutral Particle Beam (NPB)		20.60	74.00	89.00
Antigone		7.00	29.00	31.00
Advanced NPB Concepts			2.00	15.00
Integrated NPB Experiments			13.60	35.00
Concept & Development Definition		2.90	*7.80	14.00
Innovative Science and Technology		1.00	*7.00	TBD
Other Technology		0.65	-	-

1. Project Description: This project is comprised of six tasks. It is designed to provide for the development of particle beam technology for a space-based, boost/post-boost intercept system. The primary thrust of the program is focused on demonstrating the feasibility of space-based neutral particle beams (NPB) by demonstrating: (1) beam generation/conditioning with an accelerator, (2) lightweight magnetic optics that can steer the beam, (3) concepts for the acquisition, tracking, and pointing (ATP) subsystem, (4) divergence maintained in the environment in and around a spacecraft containing a particle beam device, (5) the feasibility of growth technology that can provide higher brightness beams, and (6) integration of key subsystems of a space-based NPB weapon.

In the NPB Technology Development portion of the program, the Accelerator Test Stand (ATS) is the major experiment demonstrating the scientific feasibility of ion beam production and acceleration. It currently consists of a pulsed negative ion source, a low energy beam transport system, and a low energy accelerator--the radio frequency quadrupole (RFQ). The ATS currently produces a beam energy out of the RFQ; however, the addition of the drift tube linear accelerator (DTL) will boost the output energy of the beam. After the completion of initial demonstrations, work will commence on the Accelerator Test Stand Upgrade (ATSU). The ATSU will evolve from the ATS by a series of upgrades that will demonstrate operation and control, as well as providing a test bed for evaluating new high brightness concepts. It would consist of a continuously operating negative ion source, a low energy beam transport system, a radio-frequency quadrupole accelerator, a high energy drift tube linear accelerator, magnetic optics for beam transport and pointing, and a beam neutralization system. The system will produce a neutral beam. A parallel effort will examine the potential for producing neutral particle beams with a higher brightness. This technology development effort involves, among other things, the development of ion sources and the investigation of laser beam cooling. In order to control the beam size at the target, a magnetic lens is required at the output of the system. It is, in fact, a magnetic version of a laser's beam-expanding telescope. Efforts in this area will develop a magnetic field beam-expander telescope, a steering magnet for an exit beam, and lightweight magnetic technology for space application. The large magnetic optics will be integrated in the Accelerator Test Stand Upgrade (ATSU).

Advanced NPB Concepts provide the resources to examine innovative approaches to high brightness, high efficiency, and lightweight concepts for space-based particle beams.

Beam Sensing and Control: A key technical issue associated with pointing and tracking neutral particle beams centers on sensing the position of the beam and establishing a reference ("boresight") between the beam's direction and the axis of the weapon tracking system. Two concepts will be investigated.

Concept and Development Definition supports the entire project by defining the technology development and demonstration plans to resolve critical space-based particle beam issues. To achieve this, three interrelated CDD tasks will be pursued: (1) concept definition for technology identification—concept synthesis and evaluation, performance allocation and requirements flowdown, supporting trade studies and technology assessment and planning, (2) demonstration definition—define, cost and schedule the ground and space demonstrations to validate critical technologies, and (3) operational weapon concept definition—provide the conceptual design of an operational system as a source of additional technology guidance and a common base for inputs needed in the System Architecture Studies.

The remaining portion of the space-based particle beam program is focused on the investigation of advanced concepts. Currently there is one primary concept under investigation. The goal of the present program is to conduct experiments that show the concept is technically feasible. The elements of the program include beam tracking, development of an efficient source, and demonstration of compact, lightweight accelerator technology.

2. Program Accomplishments and Plans: The Accelerator Test Stand was successfully demonstrated in FY 1984 with full current operation. The drift tube linear accelerator design for the ATS was completed and construction begun. An important aspect of the demonstration on the ATS is showing that the beam that exits the radio frequency quadrupole injector is properly bunched and has high transport efficiency through the drift tube linear accelerator. The required test stand was completed and will be used in the development of a continuously operating ion source.

During FY 1985, the neutral particle beam program will install drift tube linear accelerator sections on the Accelerator Test Stand and the first beam will be produced. The first major effort devoted to the design of the Accelerator Test Stand Upgrade is commencing. Work is continuing on the development of a continuous source for the required ions. Research is beginning in techniques for beam neutralization, heavy ion sources, and alternate beam bunching techniques. A rocket experiment employing a low energy accelerator is being designed. Investigation is continuing in advanced concepts (Antigone) and other advanced space particle beam concepts. Concept and Development Definition activities in FY 1985 will initiate concept definition for technology identification.

In FY 1986 demonstration of the neutral particle beam using the accelerator test stand will establish the concept. With the completion of this phase, the final design of the Accelerator Test Stand Upgrade will be

fixed. This upgrade will evolve from the Accelerator Test Stand by a series of modifications. A new ion source and accelerator cooling system will be assembled in a separate test stand to permit continuous operation. The upgrade will use a longer (in comparison to the Accelerator Test Stand) drift tube linear accelerator. The construction of the heavy ion source will be completed. The magnetic field beam expansion telescope and steering magnets for the large diameter beam expander will continue. Efforts in advanced particle beam concepts will continue with theoretical/laboratory experiments. Concept and Development Definition activities in the area of technology identification will be completed. This effort will provide concept synthesis and evaluation, performance allocation, and requirements flowdown for the space-based NPB weapons segment, supporting trade studies, and technology assessment and development planning.

In the years beyond FY 1986, neutral particle beam activities continue the development of the Accelerator Test Stand Upgrade. The upgrade will be completed and full facility operations begun. Required beam divergence will be demonstrated. The techniques demonstrated will be used to achieve the same divergence on a large diameter, high current beam. Efforts in large magnetic optics will provide a magnetic field beam expansion telescope and the development of a steering magnet for large diameter exit beam. These large magnetic optics will be integrated with the Accelerator Test Stand Upgrade and the neutralizer for an integrated ground-based neutral particle beam experiment. Key laboratory experiments related to boresighting the beam will be conducted in anticipation of the selection of a concept. Concept and Development Definition activities will conclude and be followed by a concept review.

Advanced concept investigations will establish the feasibility of the concepts of interest. Concept selection/sorting for the other advanced concepts under investigation will occur with follow-on investigations designed to establish feasibility.

D. PROJECT: 0004 - Nuclear-Driven Directed Energy Concepts

	FY 1984	FY 1985	FY 1986	FY 1987
Nuclear-Driven Systems	8.50	3.40	28.60	48.68
ATP Technology & Demonstration		2.30	19.10	22.00
Laboratory Experiments		0.20	-	23.88
Concept & Development Definition		0.50	1.00	2.80
Innovative Science and Technology		0.30	8.50	TBD
Other Technology		0.10	-	-

1. Project Description: This project supplements the DoE efforts in nuclear-driven directed energy with discrete efforts in acquisition, tracking, and pointing; concept and development definition; and innovative approaches. It contains five tasks.

The work on nuclear-driven directed energy is largely pursued by the Department of Energy and is designed to establish its technical feasibility. Equally important, the work ensures that the U.S. understands the potential impact of these emerging concepts if they were to be used against us by an adversary. It should be reiterated that emphasis in the SDI program is being given to nonnuclear weapons for defense.

SECTION IX

KINETIC ENERGY WEAPONS TECHNOLOGY (P.E. 63222C)

A. PROJECT: 0001 - Endoatmospheric Nonnuclear Kill (Endo-NNK) Technology

	FY 1984	FY 1985	FY 1986	FY 1987
Endo-NNK Technology	111.10	68.70	100.60	86.20

1. Project Description: This project is comprised of five tasks and contains research into key technologies associated with the destruction of reentry bodies within the atmosphere (endoatmospheric) with nonnuclear kill devices. The focus of this program at this time is the resolution of critical technical issues and the validation of component technologies. Upon validation of the key technologies, integration with supporting elements will subsequently lead to a complete experiment.

Endo-NNK technology development tasks in this program include:

- Seeker development
- Optical window and radome research
- Improved nonnuclear warheads
- Advanced avionics
- Propulsion systems development

2. Program Accomplishments and Plans: Specific accomplishments during FY 1984 were:

- Warhead tests against side-launched, dynamic targets
- Tests of high power conformal array antenna for a 35 gigahertz seeker
- Continued warhead database development

Planned accomplishments in 1985 include:

- Completion of initial sensor investigation
- Initiation of Phase 1 studies for alternative sensors
- Subscale and brassboard components tests

New starts are being undertaken for alternate warhead concepts. Design and fabrication of optical and millimeter wave windows, advanced guidance computers, and rapid response propulsion systems are being initiated in 1985. The critical technology components integration program plan for interceptor applications is projected to be completed in FY 1935.

B. PROJECT: 0002 - Exoatmospheric Nonnuclear Kill (Exo-NNK) Technology

	FY 1984	FY 1985	FY 1986	FY 1987
Exo-NNK Technology	0.10	49.10	109.70	148.40

1. Project Description: This project includes technology development for ground-launched (missile) and space-launched (rocket and hypervelocity gun) nonnuclear kill vehicles to intercept boosters, post-boost vehicles, and reentry vehicles above the atmosphere (i.e. exoatmosphere).

There are three major separate ballistic missile defense concepts this technology program supports:

- Exoatmospheric Reentry Interceptor Experiment (ERIS)
- Space-Based Hypervelocity Gun Experiment (Sagittar Experiment)
- Space-Based Kinetic Kill Vehicle Experiment

This project includes technology development in the areas of:

- Sensors
- Fire control technology
- Propulsion
- Structures
- Guidance and control
- Guided projectiles launched by missiles or hypervelocity guns

This project also includes the development of advanced data handling capabilities required to support sensor and guidance control technologies applied to ground- and space-based missiles and hypervelocity guns.

2. Project Accomplishments and Plans: Experimental flights were successfully completed in 1984. The primary experiment, the Homing Overlay Experiment (HOE), successfully demonstrated the feasibility of nonnuclear kill of reentry vehicles. This experiment formed the basis for the ERIS demonstration program.

Initial FY 1985 activity has emphasized system concept formulation and utility analysis and Technology Requirement Definition as well as Component Tests. These support the task definition and subsequently the program planning to expand the Exo-NNK technology base. The concept formulation and utility analysis efforts will culminate in the selection of various concepts to be pursued at greater depth in later phases.

Design studies for variations of the hit-to-kill interceptor design include:

- Fire control
- Warhead design
- Structures
- Seekers/sensors
- Guidance and control
- Avionics
- Propulsion systems

The integration of these technologies into operational test projectiles and improved production technologies are also being investigated.

C. PROJECT: 0003 - Subsystem Engineering and Analysis

	FY 1984	FY 1985	FY 1986	FY 1987
Subsystem Engineering and Analysis	2.40	4.00	11.80	19.60

1. Project Description: This project is designed to establish the means and database for refinements and upgrades to multiple interceptor configurations. Technical issues will be identified, evaluated and integrated into a program to advance fundamental interceptor technology.

The technology development database will emphasize:

- Advanced propulsion
- Advanced guidance
- Advanced navigation
- Improved electronics

Performance assessments of components and subsystems will be determined through simulation, analysis and testing.

2. Program Accomplishments and Plans: Several advanced kinetic energy concepts were examined in FY 1984 and were consequently synthesized into the FY 1985 plan. These included various space-based kinetic kill vehicle concepts and the effect of increased launch velocity on the effectiveness of a hypervelocity gun defense system.

FY 1985 projected results will include significant technical accomplishments including seeker vehicle technology as well as seeker and kinetic kill vehicle experiments using advanced materials and new sensor concepts.

Detailed analyses will be performed to investigate the manner in which the various KEW elements can be integrated into an operational system architecture. These analyses will be used to identify necessary links between Surveillance, C^3, Battle Management, Space Power, and Space Logistics programs within the SDIO.

D. PROJECT: 0004 - Hypervelocity Launcher Technology

	FY 1984	FY 1985	FY 1986	FY 1987
Hypervelocity Launcher Technology	6.60	19.05	68.70	100.30

1. Project Description: This project is designed to develop, integrate, and demonstrate the pulse power and hypervelocity gun technologies required for space-based ballistic missile defense. This project researches the critical technology base for advanced hypervelocity guns capable of providing repetitive launch of guided kinetic energy kill vehicles to intercept reentry vehicles.

This project includes critical technology developments of:

- Advanced accelerator development
- Power conditioning devices
- Switching technology
- Test facilities

2. Program Accomplishments and Plans: An interim report on the analysis of space-based hypervelocity launchers was completed in FY 1984. Included in this report were the following accomplishments:

- First high velocity demonstration of distributed energy store railguns used to accelerate projectiles
- First demonstration of high mass, high energy gun
- First demonstration of rapid fire electromagnetic guns using a very high current switch
- Increase in homopolar energy density
- Increase in compulsator energy density

Support is being provided in FY 1985 for two new and three on-going efforts related to the analysis of electromagnetic gun systems. The two new starts are for technology efforts. Space launcher technology is addressed in the three continuation efforts in accelerator technology: coaxial accelerator technology, distributed energy supply railgun experimentation, and high pressure railgun accelerators.

These programs will utilize the technical direction generated by the space-based hypervelocity gun experiment program to generate the development requirements for the advanced technology programs.

E. PROJECT: 0005 - Novel Concepts

	FY 1984	FY 1985	FY 1986	FY 1987
Novel Concepts	2.30	9.00	29.50	29.50

1. Project Description: This project is designed to pursue innovative kinetic energy weapons concepts. The focus of this effort will be to synthesize the concepts, develop the critical technology, and use these technologies for major improvements.

These improvements center around the utility of ultra high velocity, lightweight guided projectiles to negate responsive missile threats. The initial technology development effort will include utilization studies of guided, agile hypervelocity projectiles. New concepts will be solicited from numerous sources such as universities, independent research laboratories, and industry to stimulate interest and nurture new concepts.

2. Program Accomplishments and Plans: FY 1984 accomplishments include initial concept and technology assessment (of utilizing specialized accelerators to launch projectiles to high velocities). A program plan including initial and critical experiments as well as modeling and analysis was prepared. Existing experimental facilities have been identified in which initial proof-of-principles experiments have been performed. In the past year, specially designed accelerators were used to accelerate massive plasmas to very high velocities.

The FY 1985 effort will assess and develop the technology needed for the proof-of-principle experiments. Initial test firings have been completed, and the test results are being analyzed. Other studies analyzing the use of high temperature plasmas for hypervelocity launchers have begun. Alternate concepts such as candidate novel kinetic energy weapons systems are also being selected for investigation.

F. PROJECT: 0006 - Endo-NNK Test Bed: High Endoatmospheric Defense Interceptor (HEDI)

	FY 1984	FY 1985	FY 1986	FY 1987
Endo-NNK Test Bed (HEDI)	36.80	27.60	101.92	255.07

1. Project Description: This project consists of a concept definition study initiated in FY 1984 and a follow-on experimental study of a nonnuclear high endoatmospheric interceptor. The first phase investigated alternative experiments and the required components for each experiment were identified. A functional demonstration will be carried out to validate and demonstrate the critical technology issues.

The critical technology development and functional demonstration will include sensors, seekers, guidance, and warheads. These technologies will be integrated and used for the demonstration of nonnuclear target

destruction. This demonstration will include an assessment of vulnerability to countermeasures and survivability in a simulated battle environment.

2. Program Accomplishments and Plans: In FY 1984 lead-time planning and analysis for the Defense-in-Depth (DID) and High Endoatmospheric Interceptor System (HEDI) concept definition were initiated. Four concept definition contracts were awarded. Component technology efforts were planned and preliminary analytical test models completed.

HEDI concept definition will continue in FY 1985. Guidance and control technology is in the preliminary stages of development. The performance threshold and quantitative goals for the functional demonstration are being studied.

FY 1986 funding will initiate contractor and subcontractor activity in both the design and component technology areas. Technology will continue to be developed at brassboard and integrated experimental levels.

G. PROJECT: 0007 - Exo-NNK Test Bed

	FY 1984	FY 1985	FY 1986	FY 1987
Exo-NNK Test Bed	24.20	12.70	120.70	185.90

1. Project Description: This project began in FY 1984 with a concept definition phase to explore alternative approaches to the design of interceptors that could accomplish nonnuclear kill of reentry vehicles in the exoatmosphere. The test assembly will be comprised of the off-the-shelf components where applicable. The second phase will be used to validate and demonstrate the solutions of critical issues associated with the preferred interceptor concepts.

Included in the technology demonstration assessment will be seeker, sensor, guidance, and warhead performance in a countermeasure environment. Successful completion of the second phase will provide the data necessary to project future system development capabilities.

2. Program Accomplishments and Plans: The FY 1984 work was pursued through parallel competitive concept definition studies to address the principal issues and feasibility of exoatmospheric nonnuclear kill of ballistic missiles. Critical component issues investigated during the concept definition phase were sensor and seekers, propulsion, guidance and control, and structures.

The major FY 1985 effort entails definition and approval of the functional technology demonstration program; competition and award of a prime contract to conduct the demonstration; and initiation of requirements assessment and design of interceptor components.

In FY 1986, work will be completed on the initial phase of subsystem requirements assessment and design. The selected prime contractor, major

subcontractors, and supporting government agency will determine the fundamental configuration of the interceptor and major components. The formal approval of this configuration will take place at the subsystem design review. The design determination process will require effort among all participants in evaluating alternative options, conducting analyses, and initiating breadboard test efforts for selected key subassemblies and their component parts.

The components of the missile and associated launch hardware and software will be progressively developed, integrated, and tested. Decision reviews throughout this period will assess progress to date and provide guidance and approval as required. This program will emphasize performance throughout the ballistic missile defense scenario. Tests will provide data which provide a baseline for future deployment decisions.

H. PROJECT: <u>0008 - This number is currently not in use</u>

I. PROJECT: <u>0009 - Hypervelocity Launcher Development</u>

	FY 1984	FY 1985	FY 1986	FY 1987
Hypervelocity Launcher Development	6.60	3.50	39.30	100.40

1. <u>Project Description</u>: This project concentrates on the development of technologies required to perform intercepts of boosters, post-boost vehicles, and RVs using space-based hypervelocity guns. This project also develops a treaty-compliant space experiment to validate concept feasibility. The task is divided into two areas: (1) a Ground-Based Hypervelocity Gun Experiment (GBHE), and (2) the Space-Based Hypervelocity Gun Experiment (Sagittar Experiment). The GBHE is a device to validate the feasibility of integrating projectiles in a hypervelocity gun. The Sagittar Experiment demonstrates the feasibility of: (1) using hypervelocity guns in space, (2) guidance and control of exoatmospheric projectiles, and (3) intercept of various space targets.

The Sagittar project is divided into six phases:

- Technical Requirements Definition
- Critical Technology Demonstration
- Breadboard Projectile, Fire Control, and Guidance System Fabrication
- Brassboard Interceptor System Demonstration
- Sagittar Ground Integration
- Space Test

The first three phases concentrate primarily on projectile, fire control, and guidance (interceptor subsystem) technology development and

validation. In addition, technology needs for other SDI PEs are also generated including launchers, power conditioning, surveillance, C^3/Battle Management, Prime Power, and Space Logistics. Phase four integrates the latest technology developments in the required areas into a space qualifiable experiment. Phase five performs the space experiment. This experiment will be conducted as permitted by the ABM Treaty. Phase six will involve data reduction and analysis.

2. Program Accomplishments and Plans: Efforts in FY 1984 concentrated on developing overall system technical requirements especially for hit-to-kill capability. Emphasis was placed on deriving mission requirements to generate critical technology needs. Critical technology roadmaps were developed for future program planning.

The FY 1985 program used the results of FY 1984 work to initiate critical technology development. Several major technical milestones have already been achieved in this program. These developments greatly enhance successful development of their concept.

J. PROJECT: 0010 - Kinetic Kill Vehicle (KKV)

	FY 1984	FY 1985	FY 1986	FY 1987
Kinetic Kill Vehicle	5.50	30.00	147.40	221.40

1. Project Description: This project provides for concept design, technology development, test and evaluation for a space-based, rocket powered kinetic energy experiment. This project is conducted in two parts; technology verification and concept definition.

The technology verification effort will perform critical technology demonstrations which reflect the capabilities needed by the various subsystems. Included in these demonstrations will be:

- o Off-the-shelf rocket booster technology
- o Divert rocket motor technology
- o High performance kill vehicle
- o Fire control/guidance

After technology verification, these technologies will then be integrated and subsequently flight testing of the experiment will begin.

2. Program Accomplishments and Plans: Concept formulation studies of FY 1984 on existing contracts were extended to include technical requirement definitions. Technology verification efforts were initiated in FY 1985. These efforts are investigating high performance kill vehicle design as well as booster and divert (maneuver) propulsion technology with recently awarded contracts. The Phase 1 concept definition request for proposal was released.

The KKV experiment program will be initiated in FY 1986. The results from the technology verification will enable completion of the KKV experimental design. The KKV experiment will then reach the critical design review phase.

K. PROJECT: 0011 - Terminal Technologies Integration

	FY 1984	FY 1985	FY 1986	FY 1987
Terminal Technologies Integration	0.10	32.30	130.10	91.80

1. Project Description: This program consists of the systems engineering, systems analysis, and system integration to support test activities for evaluation of technologies associated with integration of the elements of complete kinetic energy weapons system. Support activities will include experimental diagnostics and resources for assembly of experimental elements at the test site.

2. Project Accomplishments and Plans: Based on initiation of component technology efforts in FY 1984, program planning began for conducting an integrated technology demonstration. Definition of requirements for an integrated technology also began.

Award selection is being made to conduct analyses and establish goals for technology elements. Interfaces between system elements are being identified and defined. Test requirements and hardware capabilities are being developed.

Computer capability will be established for experimental trade-off analyses. Interface compatibility among experimental elements will be maintained, and instrumentation/facility requirements for testing will be developed.

This effort results in a complete simulation of the operations of and the interactions among experimental elements. It will be validated against the capabilities of the near-term feasibility demonstration subsystems and will have the capability to incorporate actual elements of the program. The culmination of this activity is an experimental validation of the feasibility of the integrated technologies.

Military Uses of Space: 1946-1991

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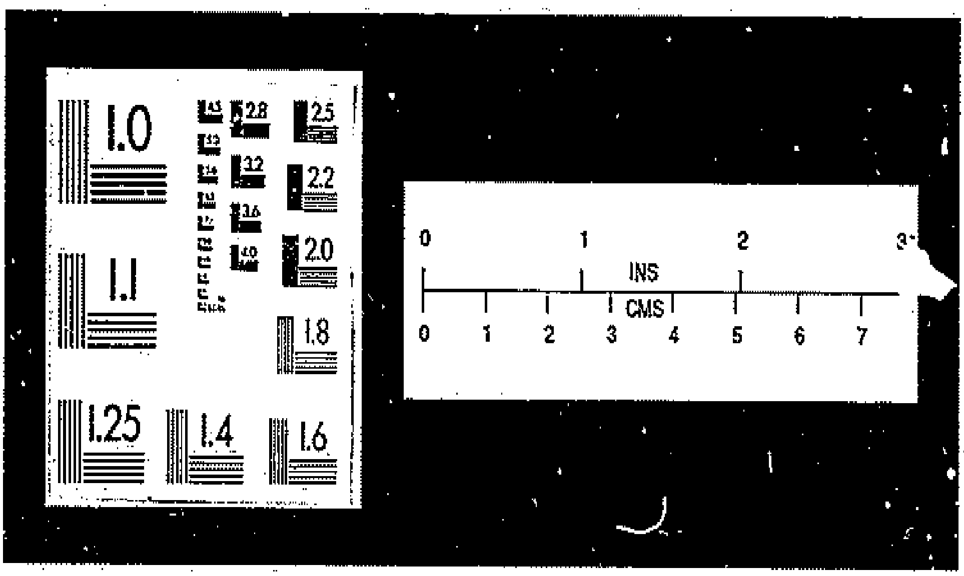

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SECTION X

SYSTEMS CONCEPTS/BATTLE MANAGEMENT (P.E. 63223C)

This program researches technologies to implement command and control systems for defense against ballistic missiles. It includes 2 projects and 10 tasks.

A. PROJECT: 3001 - Battle Management/Command, Control and Communications (BM/C^3)

	FY 1984	FY 1985	FY 1986	FY 1987
Battle Management/C^3		46.00	145.06	164.85
BM/C^3 Architecture		9.00	38.00	43.45
Processor Technology		14.50	42.80	48.60
Software Technology		13.70	44.86	50.90
Communication Technology		8.80	19.40	21.90

1. Project Description: This project has four tasks. It is designed to research technologies required to support responsive, reliable, survivable BM/C^3 for ballistic missile defense.

The purpose of the Architecture Concepts task is to define state-of-the-art BM/C^3 architectures. Studies and analyses will establish quantitative subsystem functional and technical requirements for processing, software and communications. Integrated and non-integrated systems architectures and at least two-to-four alternative architectures for the BM/C^3 system shall be developed. Battle management systems and strategies will be evaluated. The studies will include consideration of status monitoring, weapon alert, information management, attack characterization, weapon activation, weapon release, target prioritization, target assignment, self-defense coordination and countermeasure management. Emphasis will be placed on overall resource allocation and techniques for optimal allocation. An appropriate level of human interaction will be determined. In order to make choices among different architectures and to test adequately these architectures, realistic simulations that accurately model the stressed environment are needed. The requirements for these simulations and supporting facilities will be developed and initial models put into place.

The Processing Technology task is concerned with developing high performance fault-tolerant computing hardware and supporting operating systems. This effort will lead to specification of computer architectures with the requisite performance characteristics designed to operate in a hostile environment. The first step is to develop fault-tolerant strategies to meet the requirements. Alternative concepts will be based on a hierarchy of fault-tolerant detection, recovery, and error checking. Alternative fault tolerant techniques such as redundant networking, built-in-intelligence, selective component redundancy, and redundant self test and repair techniques will be researched. Detailed processor designs that are real-time, high performance, and fault-tolerant will be produced, and development plans will be written. Utilizing real-time distributed computing systems, this task

will evaluate innovative fault-tolerant techniques relative to complex distributed computing systems. Such techniques as embedded positioning, recovery algorithms, backup sparing, dynamic reassignment, and alternative voting will be evaluated.

The Software Technology task is concerned with achieving the ability to develop large, complex software systems to carry out battle management mission requirements. This effort will provide the means for developing trusted software that can be reliably modified and adapted, and algorithms and management concepts for such functions as network management, situation assessment, and weapon release in an uncertain, rapidly changing environment. The highest priority is to establish a set of software development concepts and techniques. Advanced development methodologies such as rapid prototyping expert systems, concurrency detection and exploration, and reusable software and designs will be analyzed for their applicability to support the creative software development process. Improved techniques such as program and design slicing, attribute generation analysis, symbolic execution, and forward effect tracing and analysis will be developed to assess software quality at all stages of development and preclude certain classes of errors from existing. Techniques will be developed to permit software validation testing during the development cycle. Extensive experimentation and evaluation of software development concepts will be performed to evaluate their capabilities and identify potential areas for significant improvement. A series of BM/C^3 experiments will be conducted to quantify algorithm and hardware requirements, and communication rates, for a BM/C^3 system. In conjunction with system definition efforts, a set of BM/C^3 computing requirements will be generated. Techniques to allow implementation of algorithms in a geographically distributed network will be developed. The issues of data management, fault-tolerance, data communication, and control will be investigated in developing a system-level specification for a large-scale systems network controller. Development of algorithms for situation assessment, kill assessment, damage assessment, defensive firing strategies, and network management will also be initiated.

The Battle Management Communications technology task includes the analysis of communication network requirements, definitions of network architecture, identification and development of technology requirements, development of a candidate system test bed, and evaluation through simulation of the communications systems. Network architectures based on results of the analyses conducted in the Systems Architecture project will be prepared and investigated with respect to system switching and netting, link description, and aspects of vulnerability and survivability. Initial technology investigations will concentrate on state-of-the-art technologies that have application to SDI battle management communications. In addition, technology development programs to satisfy battle management communications network requirements will include radio frequency (RF) subsystems, antennas, networks and switching, signal processors, and laser communications. Based on these efforts, a candidate communication network will be designed, developed, and evaluated using software and hardware simulation.

2. Program Accomplishments and Plans: Since BM/C^3 technology required to support the President's SDI is significantly more complex than that being pursued in previous Army and Air Force programs in this area, early emphasis was on assessing approaches and defining research and advanced technology

programs for each of the tasks. Critical technologies to be pursued and data needed to define requirements were identified in FY 1984 for each area, and program plans were defined.

A baseline set of system requirements in the Architecture Concepts task are being defined to drive the development of fault-tolerant concepts, technologies and design. Based on these requirements, critical circuit technology developments are being initiated that can withstand both high radiation dose rates and single event upsets. Combined hardware and software techniques are being developed to make the resulting system resilient to temporary faults as well as catastrophic failures in major subsystems. The goal is to develop a system that can operate in space for ten years without maintenance.

An initial set of requirements for software development technologies in the Processing Technology task is being defined based on analyses of the BM/C^3 functions needed. These requirements are being matched against existing software development structures, and a set of technology enhancements will be defined. Alternative software development approaches are being selected for further development. The selected approaches must offer the potential for efficient generation of software that can be formally specified and verified. Automated tools needed to assist in the software development process are being defined.

Beginning in FY 1985, and continuing through FY 1989, studies in the Software Technology task are being made on the speed and accuracy with which human test subjects can assess situations and make decisions. Performance is being compared as a function of the format and content of the data displayed, in situations that realistically represent possible battle scenarios. Data is being developed for evaluating the feasibility of various command doctrines and the usefulness of automated aids under stress.

For the Battle Management Communications task, beginning in FY 1985, and progressing through FY 1987, protocols are being developed for an internetted communications system to support multi-tier defenses. This network is to be self-managing and capable of providing arbitrary connectivity between any pair of points. Protocol development must support real-time communications with low delay, priority messages, self-diagnosing and self-healing capabilities, and dynamic load balancing. Alternative candidate network configurations are also being analyzed to assess their ability to satisfy the requirements defined in FY 1984. Among these candidates will be DARPA's Airborne Packet Network. Also, under this task, 60 gigahertz microwave and laser carrier links needed to support the internetted communications system are being defined.

Candidate algorithms for key battle management applications are being developed for evaluation. These algorithms must be suitable for use in a widely dispersed, loosely coupled, real-time distributed computing system. Low delay, minimum overhead and fault-tolerance are required to maintain a high level of object correlation and data base consistency and to provide robustness in the presence of network or component failures. The role of knowledge-based systems and artificial intelligence in BM/C^3 functions are also being evaluated.

Based on efforts undertaken in FY 1985, work will continue on the development of fault-tolerant information processing concepts, technology and design; software development techniques which lead to high-confidence, error-free software systems; battle management algorithms; and communications network technology, concepts and protocols.

Critical circuit technology development will continue. Results from the efforts in hardened microelectronics and fault-tolerant computing will be combined with research on high performance architectures to build machines with the performance and reliability to support battle management. A fault-tolerant architecture will be defined. Space-qualified hardware will be fabricated and tested.

Development of methodologies and tools needed to support the entire software life cycle will continue. All of the work will be closely keyed to the actual BM/C^3 system needs. Whenever possible the methods and tools developed will be applied to intermediate SDI system demonstration. Facilities designed for critical test of the software generation processes will be available. Detailed methods of generating verifiable software and automated tools to permit efficient software generation will be available.

A goal of this project is to have an adequate basis for defense activation doctrine and for design of command interfaces in a ballistic missile defense system. A simulator or simulators that would be used for testing and refining interface designs, and for training and demonstration purposes will be implemented.

Beginning in FY 1986, two candidate network approaches will be developed and experimentally verified, using the defined network protocols. A program will be initiated to breadboard and test in the field a ground-air-space internetted system. This long-term project will serve as a test bed to refine and make operational the concepts for network communications defined earlier in the programs.

Development of algorithms for the BM/C^3 functions will continue. Artificial intelligence concepts will be incorporated into the algorithms wherever potential payoffs exist. As sensor and weapon technologies become better defined, the early algorithms based on initial assumptions will have to be refined. Test facilities will be developed to aid in evaluating these algorithms for completeness and computing requirements and for testing them in simulated environments.

B. PROJECT: 3002 - SDI Systems Architectures

	FY 1984	FY 1985	FY 1986	FY 1987
SDI Systems Architectures		53.00	98.24	107.68
Threat Analysis		5.80	10.68	11.69
Systems Architecture Studies		20.00	35.20	24.29
Pilot Architecture Study		3.10	2.00	2.00
Program Integration		2.50	5.00	5.00
Functional Analyses & Modeling		6.00	16.10	24.80
Systems Concepts & Simulation		15.60	29.26	39.90

1. Project Description: This project is comprised of six tasks. It will establish system architectural alternatives based on defense missions and objectives, threat assessments, and weapon/sensor technology assessments. From these candidate architectures, system component performance requirements will be derived.

The Threat task will provide projections of possible ballistic missile threat force structures usable against the U.S. and its Allies. Analyses will be conducted to define responses which might be invoked to counter defense concepts. All information will be maintained in a centralized data base.

The Systems Architecture task is structured to define and evaluate candidate system architectures, system concepts, and parametric tradeoffs leading to the evaluation of preferred architectures. This will allow assessment of key technologies and system functions. The pilot architecture being developed by a team from Federal Contract Research Centers (FCRCs) and National Laboratories will provide an early formulation of these system architectures and tradeoffs and an initial reference to SDIO for evaluation and comparison of alternative architectures that are developed by industry contractors as part of the SDI System Architecture and Key Tradeoff Study.

The Program Integration task is designed to synthesize and integrate the data generated by the systems architectures and coordinate the technical inputs at the systems level with the technology programs in other SDI program elements. Additionally, the adequacy of the industrial base necessary to support the SDIO plan and perform studies and analyses that permit the implementation of cost saving measures will be evaluated.

The Functional Analyses and Modeling task will analyze cross-cutting system functions such as discrimination, track data base and handoff, and kill assessment. These functions are pervasive throughout a multi-tiered defensive concept and must be planned for in an integrated manner. The requirements of these functions will undoubtedly drive the data processing requirements for which the battle management technology effort must provide the necessary research.

The Systems Concepts task is structured to define boost, post-boost, midcourse, and terminal system performance requirements. Detailed trade studies will support cost-effective concept decisions and analyze key issues concerning functional requirements for system components. Advanced technologies will be evaluated in a systems context to ensure that risk is properly assessed. A detailed multi-tier computer simulation will integrate models of interceptors, sensors, and BM/C^3 in order to do component tradeoff studies and derive effectiveness estimates of each tier.

2. Program Accomplishments and Plans: Emphasis in FY 1984 was on defining the baseline threat and generation of baseline SDI system requirements.

In coordination with the intelligence community, a time-phased expected strategic threat and attack scenario was defined. Strategy and policy issues, and constraints are regarded as inputs and outputs. Architecture methodology and selection criteria are under development. Analyses and evaluation of boost, post-boost, midcourse, and terminal phase SDI concepts

initiated in previous years were continued. Strawman system conceptual designs and iterated allocation of resources and constraints among defense phases in sufficient detail to document initially perceived SDI system requirements were developed. Architectural systems and cost models with interactive application and refinement to the architectures were chosen on a more generic level. Examination of the impact of future technologies and national resources on strategic defenses, strategy and policy is beginning.

To supplement the initial analytical approaches, the FY 1985 effort is concentrating on developing modeling capability and simulation facilities (hardware and software) that provide the flexibility to analyze and evaluate evolving technologies and system designs as well as responsive enemy threats. Emphasis is on developing system-wide compatible simulations.

An initial baseline threat document is being published. Threats and scenarios are being continually reexamined and reanalyzed as new data is collected. Flexible threat drivers are being developed to input system simulations.

Analyses and evaluations of all phases of a multi-tier defense system are continuing, but emphasis is on modeling the various subsystems such as sensor-weapon platforms, and battle environments such as sensor noise backgrounds. In addition, component and subsystem cost models are being developed as technology evolves. Simulations that allow realistic measurements of system performance are being constructed, to the degree possible, for an evolving system design. These simulations should provide the major tools for (1) evaluating parametric trade-offs of alternate technologies/concepts; (2) accurately determining weapon leakage and defense system survivability; (3) estimating defense system degradation under various attack scenarios; and, (4) conducting cost-effectiveness comparisons of alternate technologies/approaches.

Detailed analyses are being made of multi-tier BM/C^3 issues, and development of a BM/C^3 national ground test facility and development evaluation facilities are being initiated. System engagement simulation models that incorporate realistic BM/C^3, Soviet threat and environment models are being defined and developed to assist mission evaluation and performance requirements generation. Preliminary concepts of operation are being determined and pacing technologies identified.

Projections and impact studies of potential future technologies and national resource requirements are continuing in an effort to identify likely drivers in weapons, sensors, support, operations and maintenance for a projected multi-tiered ballistic missile defense.

The evaluation and analysis of evolving SDI technologies and designs with emphasis on the internal system interfaces are continuing. The analysis of potential responsive threats with which the system will have to cope and the development of appropriate scenarios for use in system simulations and evaluations is being pursued. The detailed analysis of multi-tiered battle management/C^3 issues and architectures is also continuing. The concept definition of a development evaluation facility is expected to be completed.

SECTION XI

SURVIVABILITY, LETHALITY AND KEY TECHNOLOGIES (P.E. 63224C)

This program includes technology for enhancing survivability, reducing uncertainties regarding kill mechanisms and vulnerabilities, evaluation of countermeasures, investigating the needs of logistics, and improvement of space power. It includes 4 projects and 16 tasks.

A. PROJECT: 0010 - System Survivability

	FY 1984	FY 1985	FY 1986	FY 1987
System Survivability	9.20	36.20	72.15	88.70
Survivability Assessment		1.50	3.45	4.90
Survivability Analysis		3.60	5.00	6.00
Threat Refinement		3.00	3.25	5.10
Countermeasures Development		28.10	60.45	72.70

1. Project Description: The SDIO is charged with the responsibility of conducting research on promising technologies and evaluating concepts for defense-in-depth systems. Such concepts must be affordable and possess two major attributes - effective kill capability and enduring survivability.

The Survivability Project is a balanced set of four tasks that will concentrate on efforts to: (1) describe more fully a threat, (2) assist in the development of a system architecture with adequate survivability, (3) develop hardening techniques, and (4) develop active and passive countermeasures. The project is structured to satisfy the needs of the systems analysts, systems designers, and technologists in their efforts by: (1) identifying promising survivability concepts, techniques, and tactics, (2) ensuring such concepts and tactics are evaluated in the context of performance of and penalty to SDI candidate systems, (3) developing the generic technology base for systems designers to apply the effective survivability measures to designs of candidate systems, and (4) defining a threat to support survivability evaluation and countermeasures development.

A more detailed description of a threat will be developed to investigate survivability needs and develop a broad data base for selecting survivability technology and techniques. An analysis and evaluation capability is being further developed and refined to: (1) survey, document, and periodically update the status of survivability activities, (2) assist the Systems Architect in survivability matters for development of the architecture and making engineering decisions, and (3) develop a set of recommended systems requirements for a survivability data base. Based on the threat and systems needs, a technology data base will be developed for use by systems designers. In the countermeasures area, a major effort will be undertaken to investigate promising technologies.

2. Program Accomplishments and Plans: A number of Service and Agency programs have examined the problem of space system survivability and funded

the development of the requisite technologies. Portions of these on-going programs were moved into the SDI survivability program in FY 1985 and beyond. In FY 1984, efforts were focused on SDI issues to ensure that the Services and Agencies responsible for executing SDI would be in a position to use effectively funding appropriated in successive years. Experimental data and analytical results pertaining to the response of spacecraft components was compiled.

Activities in FY 1985 have continued the basic technology program. Survivability/endurability requirements and goals for system elements are being defined. The performance capabilities of candidate technologies are being defined. Testing of selected materials and concepts will be conducted, and nuclear-hardened detector development has been started. Promising materials and configurations are being explored. In the countermeasures area, a multiyear development and test program is planned to support system concept definition efforts. In FY 1985, requirements and concept studies initiated in FY 1984 are being completed, and the design/development is continuing. Competitive contracts have been initiated.

Activities and efforts begun or transferred into SDI in FY 1984 and 1985 will continue in FY 1986. A major change is being made to bring focus on these activities into synchronism with the plans of SDIO, so that informed decisions may be made in the early 1990s. Survivability experts working within this project are participating with the groups involved in SDI. They are also reviewing and will continue to review contractor activities concerning investigations relative to survivability. Most of these experts are also participating in activities that bring a significant cross-fertilization of concepts and development to relevant activities. This consultation and cross-fertilization will make a major contribution to SDI efforts in FY 1986 and for the following several years.

There is an urgency for prerequisite information on policy and strategy for a strategic defense. Some preliminary suppositions regarding a threat have been generated. Part of the FY 1985 activities has been to make intelligent assumptions on strategy against a postulated threat. In FY 1986, analysts and technology investigators will proceed with the four major tasks, using the results available from the pilot architecture and the initial Phase I System Architecture Studies.

Specifically, several independent top-level assessments and analyses will be initiated by SDIO to provide hard, discrete information on a number of issues concerning the overall survivability policy and strategy associated with SDI. Several contracts will be undertaken to stimulate innovative thinking and evolve bright ideas for enhancing survivability. The analyses task in FY 1986 will continue including construction and refinement of the set of options for negating or mitigating a threat. It will include a preliminary analysis of tactics and techniques, and an evaluation of the status of survivability activities in relevant systems projects. In addition, this task is expected to generate a set of recommendations for improving survivability in systems concepts where required. The task on active and passive countermeasures is expected to require the largest increase in funding for the survivability project in FY 1986. The increase will be incurred as a result of the need for substantial investments in a number of investigations.

There will also be some laboratory testing and simulation performed for some of the more advanced and less complex techniques. Initial guidelines for hardening will be developed. Engineering compatibility analyses will be performed. A design handbook will be generated for use in designing protection of space assets. It is anticipated that significant progress in active countermeasures will be made in defining the requirements. Overall countermeasure design projects should produce some significant concepts.

It is evident that there are commonalities and some mistakenly perceived duplications between survivability and lethality projects. There are instances when common projects can yield information for both fields. In fact, there are far more voids of information in both areas than there are potentially duplicative activities. There will be substantial coordination in FY 1986 to ensure the most efficient use by technologists in both areas and to design projects that meet common needs.

Survivability is not an end item of itself but a vital attribute to the design of a strategic defense. As such the whole program is designed to determine what is occurring in survivability; to assist others in making best use of technology and techniques; to assist in the development of evaluation techniques and engineering solutions; and to develop a wide-use survivability technology base for designers. To these ends, this program is designed to have an expert grasp of technology and information adequate to support decisions regarding strategic defense survivability in the early 1990s.

As a system architecture matures, there will be an evident need to increase specific and discrete support for evaluations of systems concepts. As systems concepts are described more adequately, there will be a continuing vigorous program which both anticipates systems designers and evaluators. At the same time, there will be continuing efforts to extend the knowledge concerning technology and ideas that show promise in enhancing survivability.

Projects involving both active and passive countermeasures may require some flight and space experiments, or other extensive laboratory and assurance testing.

B. PROJECT: <u>0011 - Lethality and Target Hardening</u>

	FY 1984	FY 1985	FY 1986	FY 1987
Lethality and Target Hardening	11.30	63.30	103.50	121.60
Thermal Lasers		23.70	22.25	24.50
Impulse Lasers		8.10	14.95	12.30
X-Ray Lasers		8.20	20.35	28.50
Particle Beams		7.00	8.25	9.90
Kinetic Energy		10.00	23.55	26.50
High Power Microwaves		6.30	14.15	19.90

1. <u>Project Description</u>: The report of the Defensive Technology Study Team cited the importance of lethality and target hardness efforts by noting that accurate knowledge will be needed of the effects that various weapon

concepts have on targets. This project has six tasks. Its purpose is to determine the comprehensive effects on damage to and vulnerability of a variety of targets. Test data will be used to validate theoretical models of the response of electronic subsystems and will determine the induced structural response and failure modes. In addition, the data base developed will be provided to the Systems Survivability project and will be used as the initial basis for estimating the vulnerability of potential U.S. defensive systems to foreign threats. This information will allow technical trade off evaluations to be made and will support decisions on which specific ballistic missile defense system concepts might be selected for further development. Testing on realistic systems and mock-ups will allow determination of weapon lethalities before large investments are made. Hardening techniques will be developed, incorporated into system testing, and evaluated with respect to performance, mission impact, cost, maintainability, and survivability to collateral effects. All SDI Lethality and Target Hardening efforts will be closely coordinated with complementary weapon research efforts in the Department of Energy.

2. Program Accomplishments and Plans: For a number of years, various Service and Agency programs have funded limited examinations of lethality and target hardness issues for particular applications. Portions of these programs were integrated into the SDI lethality program in FY 1985 and beyond. The funding reflected in FY 1984 in SDI was used to focus these on-going efforts on SDI issues to ensure that the Service and Agencies responsible for executing SDI were in a position to effectively use funding appropriated in FY 1985.

A number of subscale experiments were conducted in certain facilities (Laser Test Range, the Sandia Optical Range, the Air Force Weapons Laboratory, the Department of Energy Laboratories, numerous universities, and other laboratory laser facilities) to provide a detailed understanding of material and structural response. Validation experiments were conducted and assessments were performed using existing data. Design of initial test samples and test hardware is being completed during FY 1985, and material hardening evaluated based on preliminary test data. Test methodologies will be constructed and applied to component, subsystem, and system testing. Analytical and computational tools are being developed to determine technical feasibility and cost impacts.

Lethality and Target Hardening efforts initiated in FY 1984-1985 will continue in FY 1986 with emphasis on testing at the dedicated test facilities.

C. PROJECT: 0012 - Space Power and Power Conversion

	FY 1984	FY 1985	FY 1986	FY 1987
Space Power and Power Conversion	2.00	11.00	63.80	76.80
Multimegawatt Management		1.00	3.20	3.90
Multimegawatt Industry Concept		1.00	3.20	3.90
Multimegawatt Lab Concept		1.00	3.20	3.90
Multimegawatt Technology			38.20	45.40
SP-100 (100 kWe Class)		8.00	16.00	19.70

1. Project Description: The vast majority of electrical power used on current spacecraft is generated using solar arrays. Other techniques need to be investigated to satisfy the needs of the various elements of any deployed, multi-tiered defense system. This project has been established to develop power generation and conversion technologies capable of providing large quantities of specially conditioned electrical power for SDI needs. This project consists of two primary tasks: the joint SDI/DOE Multimegawatt (MMW) task and the joint SDI/NASA/DOE SP-100 task. (A third possible task, generic power conditioning, is under consideration but is not included in the current budget figures.)

SP-100 is a 100-kWe-class nuclear power subsystem which can be expanded to power levels of 1 or 2 megawatts. This technology is needed to provide not only moderate continuous power levels for various SDI missions, but also as an enabling technology for several NASA and non-SDI military missions planned for the 1990s. DOD representation in the tri-agency SP-100 project was transferred from DARPA to SDIO in October, 1984. In FY 1985, the SP-100 project is completing the system definition and concept selection phase, and is proceeding into engineering tests of critical components in FY 1986. The major elements of the current phase are safety, mission analysis and requirements, system definition, and supporting technology development.

The MMW project is being initiated in FY 1985 to address the SDI requirements for both high-level continuous power and burst-mode power. The objective of the MMW project is to advance the technology sufficiently by 1991 so that ground engineering subsystem development can be initiated on one or two concepts that have the potential for satisfying mission requirements within acceptable cost and mass constraints. The strategy is to: (1) solicit and evaluate a broad spectrum of potential concepts from industry and laboratories, (2) narrow the number of potential concepts to 5 or 6 by early FY 1986 and embark on both generic and concept-specific technology development, (3) further narrow the number of concepts to 2 or 3 by FY 1988 and focus the primary technology efforts in support of these concepts, and (4) continue to develop the data base for these concepts to enable selection of the design(s) for ground engineering test. Both nuclear and nonnuclear power sources will be evaluated. Examples of power conversion options include open and closed Brayton cycles, Rankine cycles, magnetohydrodynamics, and thermionics. To support the SDI power subsystem development activities, an independent evaluation group (IEG) is being formed in FY 1985. The functions of the IEG are to: (1) advise the SDI Space Power Project Office on the technical merits, trades, and technology needs of proposed concepts, (2) to identify and track the evolving SDI power subsystem requirements and interfaces through coordination with other SDI program elements, and (3) to provide power subsystem analysis and models to support SDI Systems Analysis (P.E. 62223C).

2. Program Accomplishments and Plans: The SP-100 project proceeded on-schedule and within cost in FY 1984. The primary areas of study were system definition, technology development, safety, and mission analysis and requirements. Three systems contractors were selected to continue preliminary design and analysis of baseline, backup, and growth configurations. The project focused on identifying and resolving the technical feasibility issues associated with three candidate systems: (1) a fast liquid-lithium

cooled reactor coupled with an advanced thermoelectric converter, (2) an in-core thermionic system with a pumped sodium-potassium coolant, and (3) a relatively low-temperature fast reactor coupled with a free-piston Stirling engine system. Safety issues have been identified for all three systems, and independent criticality analyses are being performed for both normal operation and accident modes. Within the technology development activity: (1) a high-efficiency, lanthanum sulfide, n-type thermoelectric material has been tested successfully on a laboratory scale, (2) candidate insulator materials for long-life thermionic cells are identified, (3) and a contract was awarded to build a 25kWe free piston Stirling engine to verify scale-up capability and operation at low temperature ratios. Mission studies have identified an abundance of military, NASA, and commercial payloads which are enabled by or could benefit from the SP-100 power system technology. As an extension of the SP-100 project, several preliminary configurations for providing continuous and burst-mode multi-megawatt power levels were generated to aid in the planning of the MMW project.

The SP-100 continues to focus on the system analysis and supporting technology development necessary to allow a single baseline configuration to be selected in July 1985 for subsystem and component engineering tests. These development tests are necessary to enable a flight prototype system to be available in time to support "near-term" military missions in the mid 1990s, should such a decision be made. Technology development activities to support the July 1985 decision include in-pile testing of candidate full-clad combinations, irradiation tests of thermionic cell insulators, continued work on a high-efficiency, p-type thermoelectric material, and initiation of tests on the Stirling engine. Safety evaluations of the three configurations is continuing. Guidance is being issued on reentry design options. Mission analysis is being expanded to include payloads requiring moderate levels of continuous power. In the area of management, a new Memorandum of Agreement among the participating agencies is being prepared for Phase 2.

FY 1985 is primarily a planning year for the MMW project. The FY 1985 budget allows for only top-level configuration studies and screening of these concepts. The key activities in FY 1985 are: (1) establishment of the MMW SDI/DOE management structure including a supplemental Memorandum of Agreement, (2) formation of the IEG, (3) solicitation and assessment of advanced concepts for MMW subsystems and components, (4) screening of concepts for further development in FY 1986, and (5) revision of the technology development plan to reflect the generic and concept-specific technology needs of the MMW power subsystems.

Having selected the SP-100 configuration for a ground engineering system in FY 1985, the main programmatic milestone in FY 1986 is selection of and awarding of the contract to a systems contractor to do the detailed design and development of the test articles. The major test item is the reactor which will be the first space reactor built in the United States in over a decade. An appropriate DOE site will be selected for the reactor test. The other engineering tests to be performed include the power conversion, heat transport, and heat rejection subsystems. The technology data base developed under the SP-100 project can be applied directly to the MMW project.

For the MMW project, FY 1986 marks the beginning of the technology development effort needed to support the selection to the final feasibility decision on the ground engineering configuration(s) and contract awarding of the follow-on studies. Program risk is highly dependent on the number of concepts which can be studied in FY 1986 and FY 1987 since SDI power requirements are evolving during this time period, and many technical feasibility issues associated with the power subsystems need to be identified and addressed. The focus of the effort is on identifying power subsystems which are reliable, survivable, and affordable within the context of the SDI architecture, and resolving the related feasibility issues. Large reductions in power subsystem mass are necessary before deployment will be practical. Design analysis and configuration optimization studies on approximately six concepts will be initiated and continue through FY 1986. Both the generic and concept-specific technology development activities will be initiated at the beginning of the fiscal year. Both nuclear and nonnuclear concepts and technologies will be pursued. The generic technology areas include nuclear fuels, surety, power conversion, materials, thermal management, energy storage, and controls and instrumentation. Power subsystem modeling and analysis tasks will continue through FY 1986 to support both the IEC and SDI Systems Analysis (P.E. 62223C).

Ground engineering tests of the major SP-100 subsystems will be completed in FY 1990 at which time technical feasibility will have been established. This schedule is based, of course, on total anticipated funding levels from the three participating agencies. It is expected that the timeframe of the initial mission for the SP-100 technology will have been established firmly by the end of Phase 2 and that the project will be restructured at that time. For the MMW project, selection of candidate concepts will continue through FY 1990 followed by a decision on which design or designs will proceed into ground engineering tests.

D. PROJECT: <u>0013 - Space Logistics</u>

	FY 1984	FY 1985	FY 1986	FY 1987
Space Logistics	1.00	1.50	18.70	29.60

1. Project Description: The Defense Technologies Study and on-going analyses have indicated that the economic feasibility of multi-layered ballistic missile defense systems against a fully responsive threat may well depend on our ability to reduce significantly the cost of logistically supporting such systems. This project funds the definition of various space logistic architectures, and the identification and development of the needed technologies. Areas to be investigated include, but are not limited to, heavy lift launch orbit-to-orbit assembly/servicing, robotics, reusable systems, and advanced cyrogenic engine systems. Because both NASA and the Air Force have interest in future space logistics infrastructures, joint studies are envisioned. In addition, it is not clear that there is adequate knowledge of a logistics infrastructure to support a complex space force of the magnitude and complexity envisioned. This project is established to: (1) pursue research in these areas, (2) bring a logical focus to work on

potential relevant technologies, and (3) construct a body of knowledge which would contribute to making an informed decision regarding systems development.

2. Program Accomplishments and Plans: The Air Force and NASA were advised of the recommendations and conclusions of the DTS in the space logistics area and a small supplemental funding of less than $1 million was directed in FY 1984 to focus on-going efforts on SDI issues.

The primary objectives in FY 1985 are to structure a management organization and to complete planning for outyear investments. A joint SDIO/Air Force/NASA Space Logistics Study is being initiated to examine the total infrastructure and capabilities need to satisfy emerging SDI requirements. Critical trade-offs between competing approaches to more cost-effective space transport are being conducted including the key trade-off between assembly on orbit and launch of integrated payloads. The principal output from this study will be: (1) a detailed investment strategy for technology funding in FY 1986 and the outyears, and (2) support to system architects and system designers in the area of space logistics. Technologies that are candidates for funding include improved cryogenic engines, reusability of lift and transfer capabilities, and zero-gravity transfer of propellants; the infrastructure of an entire logistical support network; and a refined investment strategy to provide the expert body of knowledge to make informed decisions.

Efforts should be completed on the initial study to describe both the immediate and longer term goals for research, the more promising technology pursuits, and a reasonable investment strategy. This study will be continued and expanded to examine more thoroughly the underlying foundation and framework of the logistics network to determine its extent and role in any defense force. It will be integrated with the overall SDI architecture to assist in establishing the needs of the major systems, criteria for evaluating logistical support in the system, and in offering engineering solutions. Parametric studies will be performed to measure pay-offs for promising technologies. Research programs will be initiated notably in cryogenic engine technology. Other initiations will depend on the results of the initial study. Continued studies will be funded at approximately $4-5 million. Various technology research efforts will be funded using the balance of available funding. There will be a high degree of cooperation between the Air Force and NASA on this project.

Goals are being established so that enhancements for the next decade can be envisioned adequately by 1990 with improved capabilities for a more ambitious force after the turn of the century. This task could be pacing for the decision whether or not to develop a system and might be a major cost driver in the overall architecture. It is clearly recognized as a program that must be time-phased with the overall objectives of the SDI.

SECTION XII

GENERAL MANAGEMENT SUPPORT (P.E. 65898C)

This program includes the support for management resources to the Director and staff of the Strategic Defense Initiative Organization. The support includes civilian pay, travel expenses, transportation, rents, contractural services, supplies, and equipment. The sole project is identical with the program.

A. PROJECT: 0001 - Program Management

	FY 1984	FY 1985	FY 1986	FY 1987
Program Management		8.00	9.22	10.00

1. Project Description: This project provides the management support resources for the SDIO Director and staff. Specifically, the Director and staff: plan and manage the resources in the five SDIO technical program elements and this management support program element; act as the primary agent for technical advocacy of the SDIO programs; support in-house efforts to conduct research in selected scientific areas related to SDIO needs; monitor and survey research into technologies of interest to the SDIO; provide liaison with the scientific community in areas of interest to SDIO; stimulate creative and innovative research that has the potential for advancing technology for the strategic defense mission; work closely with other government agencies on SDI activities; and support the Secretary of Defense in SDI matters.

The resources for this project are less than 1% of the overall SDIO budget.

2. Program Accomplishments and Plans: The SDIO was established as an Agency of the Department of Defense in FY 1984. When the SDIO subsumed the activities considered to be a part of the SDI, the Organization began to provide its own general management support.

There has been a continuing growth of the SDIO and its activities. Modest program increases in this element provide for funding to increase civilian manning to authorized levels and general management support of the Strategic Defense Initiative Organization.

SECTION XIII

RESOURCE REQUIREMENTS

The ongoing activities and resources that the Strategic Defense Initiative received at its inception consisted of many Service and Agency programs, plus resources for investing in new starts and for tailoring the existing programs to SDI needs. One such ongoing effort was the Army Ballistic Missile Defense program. A second example was the effort involved in improving missile launch detection programs for warning of nuclear attack. The majority of the resources previously planned for this first group of programs were, in fact, applied by the SDIO to that group. Intensive planning and evaluation activities over an 18-month period from March 1983 by independent study groups and the SDIO staff, supported by DoD Services and Agencies, NASA, and DoE, resulted in plans to invest additional resources to refocus and enhance these existing programs and begin needed new ones. Such planning activities will continue for at least the remainder of FY 1985.

Estimates are that the SDI will cost about $26 billion between fiscal years 1985 and 1989. This amount represents less than 2% of the defense budget, and less than 15% of the defense research budget for this period. The Department of Defense and Department of Energy had planned to request between $15 - 18 billion during this period for related research activities, even without a new focus on ballistic missile defense. Indeed, many of the new technologies, such as sensors, were already recognized to have great potential for a wide range of defense missions.

In the SDIO proposed budget, the largest single item is the Surveillance, Acquisition, Tracking and Kill Assessment (SATKA) program, which represents almost 40% of the total program. Work in weapons-related areas is about evenly divided between directed energy and kinetic energy technology. It is particularly important to note that about 5% of the SDIO budget has been reserved for innovative science and technology programs.

SDIO BUDGET SUMMARY ($ in Millions)

	FY 1985 Appropriation	FY 1986 Request	FY 1987 Estimate*
Surveillance, Acquisition, Tracking and Kill Assessment	$ 546	$1386	$1875
Directed Energy Weapons Technology	$ 376	$ 966	$1196
Kinetic Energy Weapons Technology	$ 256	$ 860	$1239
Systems Concepts/Battle Management	$ 99	$ 243	$ 273
Survivability, Lethality, and Key Technologies	$ 112	$ 258	$ 317
General Management Support	$ 8	$ 9	$ 10
Total	$1397	$3722	$4908

*Some rounding occurs.

APPENDIX A

THE STRATEGIC DEFENSE INITIATIVE (SDI) AND THE ALLIES

A.1 CONSULTATIONS WITH ALLIES ON SDI

A.1.1 CONGRESSIONAL REPORTING REQUIREMENT

The following addresses the Conference Armed Services Committee Report request on "...the status of consultations with other member nations of the North Atlantic Treaty Organization, Japan, and other appropriate Allies concerning research being conducted in the Strategic Defense Initiative Program."

Additionally, the House Armed Services Committee Report (98-691) requested that the Secretary of Defense review the feasibility of establishing a liaison committee with the Allies to coordinate strategic defense efforts. Noting "that since the Strategic Defense Initiative has generated world-wide interest," the Committee "...directs the Secretary of Defense to explore the feasibility of establishing a liaison committee to serve as a communication link between the U.S. strategic defense program and the U.S. Allies, with emphasis on coordination and sharing of strategic defense efforts."

A.1.2 STRUCTURE

The U.S. has maintained extensive contacts with its Allies on the Strategic Defense Initiative. Section A.1 outlines the various consultations that have occurred with Allied officials and discusses, inter alia, various consultative efforts planned for the future. In light of these activities Section A.1.9 then evaluates the House Armed Services Committee proposal for establishing a liaison committee.

A.1.3 PRESIDENT REAGAN'S MARCH 1983 SPEECH

On March 23, 1983, President Reagan announced his aspiration of rendering ballistic missiles "impotent and obsolete". His speech inaugurated a major policy and technology review that led to a broad and intensive research program known as the Strategic Defense Initiative. In the speech, President Reagan was clear about the strong and unbreakable U.S. commitment to its Allies and his intention to consult with them regarding this important technology review.

> "As we pursue our goal of defensive technologies, we recognize that our Allies rely upon our strategic offensive power to deter attacks against them. Their vital interests and ours are inextricably linked--their safety and ours are one. And no change in technology can or will alter that reality. We must and shall continue to honor our commitments."

> "I clearly recognize that defensive systems have limitations and raise certain problems and ambiguities. If paired with offensive systems, they can be viewed as fostering an aggressive policy and no one wants that."

"But with these considerations firmly in mind, I call upon the scientific community who gave us nuclear weapons to turn their great talents to the cause of mankind and world peace; to give us the means of rendering these nuclear weapons impotent and obsolete."

"Tonight, consistent with our obligations under the ABM Treaty and recognizing the need for close consultation with our Allies, I am taking an important first step."

Concern for and recognition of Allied interests are thus a part of the SDI effort from its inception.

A.1.4 INITIATION OF CONSULTATION

As a result of the President's speech, the two major government studies were conducted during the summer and fall of 1983 to evaluate the technical and policy implications of advanced defense against ballistic missiles. The policy study in particular examined whether and how advanced ballistic missile defenses might fit in NATO's strategy of flexible response. The studies confirmed that an effective defense against ballistic missiles could enhance U.S. and Allied deterrence and security, and that such defenses would be fully consistent with Alliance strategy. Based on the results of these studies, the President in establishing the SDI research effort, directed that consultations be held with the Allies on SDI. Thus, from the beginning of the study efforts, the U.S. has sought to ensure first that Allied interests and concerns were an integral part of the approach, and, secondly, that members of NATO and other Allies of the United States were, and remain fully aware of U.S. thinking. As the U.S. embarked on this research program, it was recognized that it was of the highest importance that the U.S. and its Allies work together on understanding the policy and technical implications of those developments for deterring both nuclear and conventional aggression.

We have been consistent in meeting the concerns of the Allies directly—at all levels of the Allied governments—by providing the Allies the U.S. view of the political, military and technological basis for SDI. The following section illustrates some of the many consultations the U.S. Government has conducted on the Strategic Defense Initiative with the Allies beginning in 1984.

A.1.5 MULTILATERAL CONSULTATIONS

a. Briefing Teams to Allied Capitals

Following President Reagan's decision on Allied consultations embodied in a Presidential Decision Directive, Administration briefing teams were sent to the capitals of Allies in Western Europe and the Pacific. The interagency teams were composed of officials from the Office of the Secretary of Defense, the Organization of the Joint Chiefs of Staff, the Department of State, and the Arms Control and Disarmament Agency. The European team briefed NATO Allies during early February 1984. The Pacific team visited Ottawa before traveling to Tokyo, Canberra and Wellington. As a preliminary step, Allied

military attaches in Washington were presented with a briefing in order to ensure that they were informed and to provide them an opportunity to pass preliminary views to their governments in the interest of facilitating discussions with U.S. representatives.

The Allies were presented a three-part briefing covering the scope of the Soviet efforts in both conventional ABM capabilities and advanced ABM technologies, the results of U.S. study of the policy implications of SDI and the dimensions of the U.S. technology research and development program.

b. <u>Ministerial Session at the Nuclear Planning Group</u>

At the Nuclear Planning Group[1] (NPG) Ministerial session in Cesme, Turkey, 3-4 April 1984, the United States presented a briefing on the policy and technology aspects of SDI.

Secretary Weinberger assured the Allies that the United States fully intended to continue consultations, noting that the briefing at the NPG and earlier briefings in the Alliance were evidence of U.S. efforts. The Secretary stressed that he would welcome Allied technical participation as this could make significant contributions to the SDI program.

c. <u>NATO Military Committee Briefing</u>

Officials of the U.S. government provided a similar policy and technology briefing to a plenary session of NATO's Military Committee[2] in July 1984.

d. <u>North Atlantic Council and High Level Group Meeting</u>

In July 1984, high ranking U.S. government officials met with the permanent representatives of the North Atlantic Council[3] and NATO's High Level Group[4] to discuss SDI. The discussion focused on the origin and purpose of SDI, implications for deterrence and arms control and the potential benefits for the Allies.

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[1]The Nuclear Planning Group (with representatives of all the NATO nations except for France and Iceland) meets at either the level of Defense Ministers or Permanent Representatives.

[2]The Military Committee is the highest military authority in NATO. Member nations are represented usually by their Chief of Staff or his permanent designated representative (except for France which is represented by a military mission and Iceland which can be represented by a civilian since it has no military forces).

[3]The North Atlantic Council is comprised of permanent representatives of Ambassador rank appointed by 16 NATO nations.

[4]The High Level Group is comprised of senior level officials from the member nation's Ministries of Defense.

e. <u>North Atlantic Council Meeting</u>

In February 1985, an interagency team briefed a morning and afternoon session of the North Atlantic Council's permanent representatives. The briefings included the Soviet efforts in research and development of defenses against ballistic missiles and a programmatic briefing on the SDI program.

A.1.6 OTHER CONSULTATION EFFORTS

In addition to the high visibility consultations which have occurred in both multilateral and bilateral fora, there have been continuous U.S. efforts to meet with the Allies at the mid-level when representatives of Allied nations come to the United States.

A.1.7 CONSULTATIONS ON TECHNOLOGY COOPERATION

Over the next several years, the U.S. will work closely with its Allies to ensure that, in the event of any future decision to deploy defensive systems (a decision in which consultation with the Allies will play an important part), Allied as well as United States security against aggression would be enhanced.

Moreover, the United States will, consistent with existing international obligations including the ABM Treaty, proceed with cooperative research with the Allies in areas of technology that could contribute to the SDI research program. Pursuant to this policy, the United States is permitted--and is prepared--to undertake such cooperative programs on data and technology short of ABM component level as may be mutually agreed with Allied countries.

With respect to SDI, the United States will not seek to arrange for the Allies to do for the U.S. what it cannot do under the Treaty. Of course, exchanges with the Allies concerning defensive systems not covered by the ABM Treaty can continue as desired by the United States and its Allies.

A.1.8 FUTURE CONSULTATIVE EFFORTS

The United States intends to continue an active dialogue with Allies on the range of policy and technical issues relating to SDI. Numerous formal and informal meetings are expected to be held over the next several months.

A.1.9 FEASIBILITY OF ALLIED LIAISON COMMITTEE

This report's description of numerous consultations which have occurred with the Allies since President Reagan announced his research program and the many consultative efforts planned for the future makes clear that the U.S. has a very active diplomatic effort underway on the SDI. It is believed that this representative sample, though not exhaustive, demonstrates that the Administration's efforts to consult with the Allies have been concerted and responsive to the concerns of the Allies themselves.

The formal multilateral mechanisms through which consultations were conducted have served as satisfactory consultative fora, particularly for the

discussion of political matters. These formal mechanisms include the North Atlantic Council, Nuclear Planning Group, High Level Group, Committee for National Armament Directors (CNAD), and the NATO Advisory Group for Aerospace Research and Development (AGARD). Since these groups are existing entities within the NATO structure, they provide established mechanisms through which NATO can hold regular meetings to discuss issues confronting the Allies. SDI has been and will continue to be a topic at those meetings. It is believed, therefore, that any additional mechanisms established would constitute an unnecessary bureaucratic layer.

These existing formal mechanisms and informal and formal bilateral discussions with Allied officials have permitted consultations with mid- to senior-level officials including individuals interested in both policy and technology issues.

The U.S. will continue to use these mechanisms to keep its Allies fully informed on its discussions with the Soviet Union on SDI-related matters, including the on-going negotiations in Geneva.

Since the SDI has implications that touch numerous aspects of Allied relations, the establishment of a single, new mechanism for Allied consultation on SDI would have a constraining--rather than facilitating--effect on such necessary consultation.

In the area of technology, bilateral discussions are important to determine the degree to which Allied technical and scientific assistance could contribute to the SDI program. Regularly scheduled, formal, multilateral meetings would be inappropriate fora for Allied technical participation due to the diversity of scientific and technical expertise of the Allies in SDI-related technologies. Additionally, setting up such a group would stifle the free flow of ideas necessary to scientific progress while at the same time creating a ponderous bureaucratic infrastructure that could consume funds without providing any technical results.

In conclusion, the Administration believes that a liaison committee for communication and coordination with the Allies on SDI is unnecessary and potentially counterproductive. It is firmly believed that this report reflects the concerted efforts over the past two years to consult closely with its Allies on SDI-related matters. The U.S. will continue to consult with its Allies on a regular basis on all issues that arise while research efforts are continued in support of the President's Strategic Defense Initiative.

A.2 EFFECT OF THE STRATEGIC DEFENSE INITIATIVE ON U.S. ALLIES

A.2.1 CONGRESSIONAL REPORTING REQUIREMENT

This section deals with the Congressional request on "...the strategic military and budgetary impact on our Allies of the Strategic Defense Initiative and related programs, including the impact of the possible deployment of Soviet missile defense on the viability of the independent nuclear forces of our Allies and other countries as well as on American policies and capabilities relative to our extended deterrence posture."

A.2.2 NATO'S FLEXIBLE RESPONSE POLICY AND SDI

Since its founding in 1949, the primary objective of the NATO Alliance has been to maintain the independence and territorial integrity of its member states by deterring aggression. While this objective has never been altered, changes in the military balance and the threat the Alliance has faced from the Soviet Union have, over the years, required periodic changes in the means by which it has been achieved.

In the years prior to Soviet acquisition of a substantial strategic nuclear capability, the U.S.'s overwhelming superiority in nuclear arms and the fact that U.S. vulnerability to Soviet nuclear attack was relatively low, meant that NATO could confidently deter Soviet nuclear or conventional aggression in Europe merely by threatening devastating U.S. nuclear retaliation against the Soviet Union. Because Soviet retaliatory options against the U.S. were limited, this policy was both simple and credible. But as Soviet strategic nuclear capability grew, this strategy became increasingly less credible.

Since 1967, the NATO Alliance's strategy to deter Soviet aggression has been based on the policy known as "flexible response". Described in NATO document MC 14/3, flexible response is based on the assumption that deterrence can best be maintained if the Alliance maintains the means—both conventional and nuclear—to respond flexibly to a wide range of potential Soviet military aggression.

Adoption of the flexible response strategy by NATO represented an acknowledgement that Soviet military capabilities, especially nuclear, had grown to such an extent that NATO's military doctrine no longer could be based solely on a U.S. threat of massive retaliation to deter all possible levels of Soviet aggression, both nuclear and conventional. This dictated a change in the way in which NATO deterred Soviet aggression. In the face of Soviet strategic nuclear equivalence, a growing arsenal of nuclear weapons capable of striking Western Europe from within the Soviet Union and Eastern Europe, and the conventional force superiority that the Soviet Union has traditionally enjoyed over NATO, the flexible response strategy called for the maintenance of a much broader mix of deterrent forces and capabilities. In the years since 1967, NATO has endeavored to develop and deploy the forces necessary to construct a "seamless web of deterrence"; that is, conventional and nuclear forces deployed in Europe and strategic nuclear forces, capable of acting together to deny the Soviet Union credible attack options, whether they be large-scale, limited, nuclear or conventional. This is the context in which the U.S. is modernizing its conventional forces and intermediate range and strategic nuclear forces.

But because Soviet capabilities through the 1970s and 1980s have not remained constant—their continuing increase in strategic nuclear intermediate-range nuclear, and conventional force capability relative to the West providing ever wider options for aggression—the challenges to NATO's security interests continue to mount. One of the central challenges to NATO's flexible response strategy is the Soviet Union's increasing intercontinental- and shorter-range ballistic missile capability. The growth of the Soviet Union's modern, accurate ballistic missile force has reached the point where it threatens NATO's ability to retaliate effectively to a potential Soviet

first-strike attack and has reduced the stability of the strategic environment.

Soviet SS-20s and other shorter-range ballistic missiles provide overlapping capabilities to initiate nuclear or conventional strikes throughout all of NATO Europe. Soviet doctrine includes the use of conventionally-armed ballistic missiles to initiate rapid and wide-ranging attacks on crucial NATO military targets throughout Europe, such as air fields, air defense sites, resupply ports, weapons and munitions storage sites, and C^3I and military headquarters facilities. The purpose of this tactic would be to reduce significantly NATO's ability to resist the initial thrust of a Soviet conventional force attack with conventional forces and to impede NATO's ability to resupply and reinforce its combatants from outside Europe. This is a serious and growing threat to the maintenance of a strong flexible response deterrent in Europe. But the threat does not end here. This ballistic missile capability also could be used to destroy quickly, at the onset of hostilities, European-based nuclear forces and storage facilities, further blunting NATO's flexible response capability.

An effective defense against ballistic missiles would offer a means of surmounting the Soviet ballistic missile challenge. Such defenses would increase significantly Soviet uncertainties regarding whether their weapons would penetrate the defenses and destroy crucial military targets. Lacking confidence in its ability to conduct a successful attack under these circumstances, the Soviet Union would be far less likely to contemplate such an attack, even during a crisis. By reducing or effectively eliminating the military utility of ballistic missiles, defenses also would reduce or eliminate the destabilizing threat of first-strike attack.

In effectively countering ballistic missile threats against the U.S., such defenses would strengthen the credibility of U.S. extended deterrence and NATO's flexible response strategy by reducing U.S. vulnerability to attack. But the contribution that ballistic missile defenses can make to flexible response does not end here. By reducing or eliminating the ability of shorter-range Soviet ballistic missiles to strike rapidly European NATO military assets essential to effective resistance to Soviet nuclear or conventional force aggression in Europe, such defenses also could enhance the ability of the U.S. to maintain an effective flexible response strategy in Europe. They thereby could increase deterrence against Soviet nuclear or conventional force attack in that region and strengthen the coupling between U.S. and NATO forces.

NATO always has been a defensive alliance, eschewing the aggressive use of force against other states and rejecting the deployment of military forces that could support an aggressive policy. Thus, SDI is more than just consistent with the military requirements of the Alliance. Because it embodies a defensive purpose, it also is consistent with the Alliance's defensive philosophy.

Just as deterrence against attacks directed at the U.S. and its European Allies could be enhanced by effective defenses against ballistic missiles, such defenses also would deter attacks against other important Allies of the United States. This is especially true of those Allies for whom Soviet ballistic missiles constitute the primary threat they face.

A.2.3 INDEPENDENT NUCLEAR DETERRENTS AND SDI

Related to the maintenance of deterrence in Europe today are the independent deterrent forces possessed by France and the United Kingdom. These forces, as well as those of the U.S., are potentially affected by on-going Soviet ballistic missile defense efforts.

While much of the Soviet effort in this area has been consistent with the ABM Treaty, one significant program--the construction of a large phased-array radar near Krasnoyarsk--constitutes a violation of a key provision of the Treaty. In addition, the Soviets also probably have violated the Treaty prohibition on testing SAM air defense components in an ABM mode by conducting concurrent operations of SAM and ABM components. Also the development of the new ABM system mentioned above, represents a potential violation of restrictions on mobile ABM components. The sum of Soviet activities suggests that the Soviet Union may be preparing an ABM defense of its national territory--an activity prohibited by the ABM Treaty.

The extent of the Soviet ballistic missile defense effort, the persistence of the effort (the Soviet program, including that part that is developing advanced ABM technologies, has been in existence for many years and substantially predates SDI), Soviet willingness to violate the ABM Treaty, and the fact that Soviet military doctrine places great emphasis on superior defensive capabilities of all types as well as on superior offensive forces, stand as convincing evidence that the Soviets are positioning themselves to deploy wide-spread ballistic missile defenses, should they deem such defenses to be in their interest. This inclination exists independent of U.S. ballistic missile defense activities and is largely unaffected by them.

Soviet doctrine and ballistic missile defense activities will have a continuing impact on French and United Kingdom nuclear forces as well as on those of the U.S., quite independent of SDI research efforts. In this regard, the presence of an active U.S. SDI research program may reduce substantially any inclination to break-out (or creep out) of the ABM Treaty. A break-out from the ABM Treaty would be useful to the Soviets in the long-term only if the benefits could be exploited unilaterally. An active SDI program would provide an effective hedge against such unilateral Soviet options.

A.2.4 BUDGETARY IMPLICATIONS

Beyond the question of the cost of the SDI research program itself (estimated to be approximately $26 billion over the next five years), the potential budgetary impact of SDI on the U.S. or its Allies, if defensive deployments are made, cannot be assessed at this time.

Also difficult to assess at this point, but with real potential budgetary and financial impact, is the degree to which the SDI research program will further our understanding of a wide range of technologies with general military and commercial application. Due in large part to the fact that these technologies could provide budgetary and financial benefits far beyond what one might otherwise expect from a military technology research program, many of the Allies have expressed an interest in active participation in the SDI program.

APPENDIX B

THE STRATEGIC DEFENSE INITIATIVE (SDI) AND THE ABM TREATY

B.1 COMPLIANCE OF THE STRATEGIC DEFENSE INITIATIVE WITH THE ABM TREATY

B.1.1 INTRODUCTION AND SCOPE

The following addresses "... the status, from the present year to completion, of each Program, Project and Task under the Strategic Defense Initiative and related programs with respect to compliance with the ABM Treaty." The likely need for modification to the ABM Treaty to proceed beyond the SDI research program is discussed. The existing process for ensuring compliance with Strategic Arms Limitation (SAL) Agreements, including organizational responsibilities and reporting processes and their application to SDI and the ABM Treaty, is also described.

The President's Strategic Defense Initiative, January 1985, makes clear that SDI is a research program. It states:

- "The President announced his Strategic Defense Initiative in his March 23, 1983, address to the nation. Its purpose is to identify ways to exploit recent advances in ballistic missile defense technologies that have potential for strengthening deterrence and thereby increasing our security and that of our Allies. The program is designed to answer a number of fundamental scientific and engineering questions that must be addressed before the promise of these new technologies can be fully assessed. The SDI research program will provide to a future President and a future Congress the technical knowledge necessary to support a decision in the early 1990s on whether to develop and deploy such advanced defensive systems."

- "As a broad research program, the SDI is not based on any single or preconceived notion of what an effective defense system would look like. A number of different concepts, involving a wide range of technologies, are being examined. No single concept or technology has been identified as the best or the most appropriate. A number of nonnuclear technologies hold promise for dealing effectively with ballistic missiles."

B.1.2 POLICY

There are three major points to be made regarding United States Policy on compliance with the ABM Treaty.

First, the SDI research program is being conducted in a manner fully consistent with all U.S. Treaty obligations. The President has directed that the program be formulated in a fully compliant manner and the DoD has planned and reviewed the program (and will continue to do so) to ensure that it remains compliant. Specifically, our review has found that the research necessary to support a decision on the potential utility of the SDI technology can be conducted in accordance with U.S. Treaty obligations.

Second, because there are gray areas that are not fully defined in the ABM Treaty, it is necessary in some cases to set additional standards to make certain that the U.S. is in compliance.* This review has been conducted using reasonable standards of U.S. compliance. Four of the more important working principles of this review are that:

- Compliance must be based on objective assessments of capabilities which support a single standard for both sides and not on subjective judgments as to intent which could lead to a double standard of compliance.

- The ABM Treaty prohibits the development, testing, and deployment of ABM systems and components that are space-based, air-based, sea-based, or mobile land-based. However, that agreement does permit research short of field testing of a prototype ABM system or component. This is the type of research that will be conducted under the SDI program.

- New technologies and devices should not be subjected to stricter standards than have evolved for existing systems.

- The ABM Treaty, of course, restricts defenses against strategic ballistic missiles; it does not apply to defenses against non-strategic ballistic missiles or cruise missiles.

Third, this report does not consider Soviet violations of the ABM Treaty. We do reserve the right to respond to those violations in appropriate ways, some of which may eventually bear on the Treaty constraints as they apply to the United States. The United States Government must guard against permitting a double standard of compliance, under which the Soviet Government would expect to get away with various violations of arms agreements while the U.S. continues to abide with all provisions.

B.1.3 OVERALL COMPLIANCE ASSESSMENT

The entire SDI research program as submitted in the FY 1986 authorization request is being conducted in compliance with the ABM Treaty. The SDI program consists of near-term technology research projects and longer-term technology experiments. The technology research projects directly support the experiments by providing the necessary technologies. These near-term technology research projects and tasks are well defined and clearly compliant. The major technology experiments to be conducted in later years are being planned to be fully compliant. These experiments are designed to demonstrate technical feasibility, that can be established without involving ABM systems or components or devices with their capabilities. Thus, compliant space-based as well as fixed land-based experiments are possible.

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* An example is the issue of components versus subcomponents. ABM components are defined in the Treaty as currently consisting of ABM missiles, launchers, and radars. Subcomponents, which are not limited by the Treaty are not defined by the Treaty.

The SDI research program can be conducted in a fully compliant manner to reach a decision point in the early 1990s on whether to proceed to development and deployment of an SDI-related system. The compliance evaluation process is an on-going one, as current programs become better defined, new programs are added, and some programs are eliminated or modified. Development and deployment, given a decision to proceed, would almost certainly require modifications to the ABM Treaty. The ABM Treaty provides for possible amendments at any time and five year review sessions during which possible changes can also be discussed. Also, Article XV (2) provides a right to withdraw from the Treaty. In this connection, during the negotiations Gerard Smith stressed the importance the U.S. Government attaches to achieving agreement on more complete limitations on strategic offensive arms following agreement on an ABM Treaty and the interim SALT Agreement. He stated:

> "If an agreement providing for more complete strategic offensive arms limitations were not achieved in five years, U.S. supreme interests could be jeopardized. Should that occur, it would constitute the basis for withdrawal from the ABM Treaty."

B.1.4 EXISTING COMPLIANCE PROCESS FOR SDI

DoD has in place an effective compliance process (established in 1972 after the signing of the SALT I agreements), under which key offices in DoD are responsible for overseeing and will continue to oversee SDI compliance with all existing strategic arms control agreements. Under this process the SDIO, the relevant Agencies and Services ensure that the implementing program offices adhere to DoD Compliance Directives and guidelines.

Specific responsibilities are assigned by DoD Directive 5100.70, 9 January 1973, Implementation of SAL Agreements. The Under Secretary of Defense for Research and Engineering (USDRE) ensures that all DoD programs are in compliance with existing SAL agreements. The Service Secretaries, Chairman JCS and Agency Directors ensure the internal compliance of their organizations. The DoD General Counsel provides advice and assistance with respect to the implementation of the compliance process and interpretation of SAL agreements.

DoD Instruction S-5100.72 establishes general instructions, guidelines, and procedures for ensuring the continued compliance of all DoD programs with the existing agreements. Under these procedures questions of interpretation of specific agreements are to be referred to the USDRE to be resolved on a case-by-case basis. No project or program which reasonably raises an issue as to compliance can enter into the testing, prototype construction, or deployment phases without prior clearance from the USDRE. If such a compliance issue is in doubt, USDRE approval shall be sought. In conjunction with the DoD General Counsel, the USDRE applies the provisions of the agreements, as appropriate. Military departments and DoD Agencies are to certify internal compliance quarterly and establish internal procedures and offices to monitor and ensure internal compliance.

As a new agency, SDIO was instructed to submit quarterly reports certifying its compliance and to monitor its projects, as required of other DoD Agencies. The Services are to ensure that SDI projects under their

auspices are monitored and implemented in a Treaty compatible manner. They are to include SDI compliance in the quarterly reports they submit under DODI S-5100.72.

B.1.5 CATEGORIES OF TREATY COMPLIANT ACTIVITIES

There are three basic types of activity that are permitted in compliance with the ABM Treaty. The SDI major experiments described in a later section have been classified according to these categories.

Category 1 - Conceptual Design or Laboratory Testing. This activity precedes "field testing" and was considered during the ABM Treaty negotiations to be research that was not verifiable by National Technical Means (NTM) and that was not subject to Treaty limits. In testimony provided to the Senate Armed Services Committee in 1972, Gerard Smith presented the following statement:

> "The SALT negotiating history clearly supports the following interpretation. The obligation not to develop such systems, devices, or warheads would be applicable only to that stage of development which follows laboratory development and testing. The prohibitions on development contained in the ABM Treaty would start at that part of the development process where field testing is initiated on either a prototype or breadboard model. It was understood by both sides that the prohibition on 'development' applies to activities involved after a component moves from the laboratory development and testing stage to the field testing stage, wherever performed. The fact that early stages of the development process, such as laboratory testing, would pose problems for verification by National Technical Means is an important consideration in reaching this definition. Exchanges with the Soviet Delegation made clear that this definition is also the Soviet interpretation of the term 'development'."

Category 2 - "Field Testing" of Devices that Are Not ABM Components or Prototypes of ABM Components. As noted earlier, Article V prohibits the development, testing, and deployment of ABM systems or components that are space-based, sea-based, air-based, or mobile land-based.

The Smith statement shows it was clear in 1972 that "development" begins when "field testing" is initiated on either a "breadboard model" or "prototype" of an ABM component. This definition of "development" was used as a basis of ratification by the Senate and has been used as a U.S. Government standard for the last thirteen years. The definition of "development" coupled with Article V led to the prohibition on "field testing" of "ABM systems" and "components", or their "prototypes" and "breadboard models", which are other than fixed land-based. SDI "field tests" of space- or other mobile-based devices cannot involve ABM "components" or "prototypes" or "breadboard models" thereof. All SDI Cateogry 2 experiments must meet this criteria.

"ABM systems and components" are defined in Article II as follows:

> "For the purpose of this treaty an ABM system is a system to counter strategic ballistic missiles or their elements in flight trajectory, currently consisting of: (a) ABM interceptor missiles, which are interceptor missiles constructed and deployed for an ABM role, or of a type tested in an ABM mode; (b) ABM launchers, which are launchers constructed and deployed for launching ABM interceptor missiles; and (c) ABM radars, which are radars constructed and deployed for an ABM role, or of a type tested in an ABM mode."

No space-based, air-based, sea-based or mobile land-based launchers, interceptors, and radars may be "tested in an ABM mode". Toward this end, an interceptor missile is considered to be "tested in an ABM mode" if it has attempted to intercept (successfully or not) a strategic ballistic missile or its elements in flight. Likewise a radar is considered to be "tested in an ABM mode", if it performs certain functions such as tracking and guiding an ABM interceptor missile or tracking strategic ballistic missiles or their elements in flight in conjunction with an ABM radar which is tracking and guiding an ABM interceptor missile. "Strategic ballistic missiles or their elements in flight" include ballistic target-missiles with the flight characteristics of strategic ballistic missiles or their elements over the portions of the flight involved in testing.

Category 2 experiments must also meet the obligation of Article VI not to give non-ABM launchers, missiles, or radars the capability to counter strategic ballistic missiles or their elements in flight trajectory. Allowed Category 2 activities include tests of experimental devices to demonstrate technical feasibility and gather data prior to reaching the stage of prototype or breadboard model of an actual ABM component or weapon system. Tests of ABM sub-components and non-ABM systems performing functions consistent with Treaty obligations (such as air defense and early warning) are also legitimate Category 2 activities.

<u>Category 3 - "Field Testing" of Fixed Land-Based ABM Components.</u> "Field Testing" of fixed land-based ABM components or systems is permitted as long as other Treaty provisions are met. Under Article IV all tests must take place at agreed ABM test ranges (for the U.S., White Sands Missile Range and Kwajalein Missile Range) and the total test launcher count must not exceed 15. Paragraph 2 of Article V addresses limits on launcher capabilities as follows:

> "Each party undertakes not to develop, test, or deploy ABM launchers for launching more than one ABM interceptor missile at a time from each launcher, nor to modify deployed launchers to provide them with such a capability, nor to develop, test, or deploy automatic or semi-automatic or other similar systems for rapid reload of ABM launchers."

An Agreed Statement adds the prohibition on "delivery by each ABM interceptor missile of more than one independently guided warhead" to Article V.

Summary. The SDI projects and experiments have been reviewed to ensure that they will be implemented in accordance with one of the three categories of treaty compliant activities. The Services and the SDIO are obligated to plan and implement them in a compliant manner. In this assessment many of the SDI devices do not use traditional technology, but are "based on other physical principles" (such as lasers). In these cases they were reviewed by considering their capability to substitute for traditional ABM components, whether they will be "tested in an ABM mode" by analogy to the requirement for interceptors, launchers, and radars, and the intended use of the device in the experiment.

B.1.6 COMPLIANCE ASSESSMENT

The entire SDI program has been reviewed for compliance with the ABM Treaty. The bulk of the near-term effort consists of technology research efforts that support the fifteen major experiments to be conducted by the SDI Program. These technology research projects have been reviewed for compliance. The fifteen major experiments and their basis for compliance (ten are in Category 1 or 2 and five are in Category 3) are summarized below:

Category 1 and 2 Major Experiments. The ten experiments in these two categories involve devices that are not ABM components or prototypes thereof. These include the four Directed Energy Weapon (DEW)-related experiments and six Surveillance, Acquisition, Tracking and Kill Assessment (SATKA) and Kinetic Energy Weapons (KEW) experiments.

The four Directed Energy Weapon experiments are the ALPHA/LODE/LAMP, TALON GOLD replacement, integration of a high powered laser and optical devices, and the Ground-Based Laser Uplink. The Surveillance, Acquisition, Tracking and Kill Assessment projects include the Boost Surveillance and Tracking System Experiment, the Space Surveillance and Tracking System Experiment, and the Airborne Optical Adjunct Experiment. The Kinetic Energy Weapons projects include Space-Based Kinetic Kill Vehicles Experiment and land-based and space-based Electromagnetic Railgun Experiments.

ALPHA is a ground-based laser device designed to explore the potential of chemical lasers for space-based applications. The Large Optics Demonstration Experiment (LODE) and LODE Advanced Mirror Program (LAMP) are to demonstrate critical beam control and optics technologies, respectively, in a series of ground-based experiments. The LODE/LAMP mirror is to be integrated with a high power chemical laser using LODE beam control technology in the late 1980s. All of these tests are under-roof experiments using devices incapable of achieving ABM performance levels. (Category 1)

The newly constituted Acquisition, Tracking and Pointing (ATP) demonstration program replacing Talon Gold will concentrate on a series of ground-based, laboratory-level experiments in the near term. In these experiments, brassboard hardware built under the TALON GOLD project will demonstrate, with increasing degrees of difficulty, technologies required for ATP of weapons and sensors for space- and ground-based applications. In the future, the measurement of booster plumes from space is a distinct possibility. The previously designed pointer may be built for use as a stable platform for

such experiments with passive sensors in the Shuttle bay. If conducted these experiments will use technologies which are only part of the set of technologies ultimately required for an ABM component. These devices will also not be capable of achieving ABM performance levels. Follow-on experiments may make use of the shuttle to explore pointing and tracking technology. When they are defined, they will be reviewed to ensure they are in compliance. (Category 1/2)

Laser and optical subsystems from other programs will be integrated into an experimental device for ground-based testing against ground-based static targets at the White Sands Missile Range. This will demonstrate, in a ground test, the efficient integration of important subsystems, which (separated or in whole) are not ABM components or prototypes and are not capable of being based in space. The power, optics, and laser frequency are not compatible with atmospheric propagation at ranges useful for ABM applications. Tests are not planned against missiles or their elements in flight. (Category 2)

The Ground-Based Laser Uplink experiment is for atmospheric propagation experiments using a treaty compliant ground-based laser. The testing mode and capabilities are below the power level and beam quality required for a ground-based laser ABM weapon, and testing will not include strategic ballistic missiles or their elements in flight. (Category 2)

The Boost Surveillance and Tracking System (BSTS) Experiment is a space-based experiment (which is not fully defined) to demonstrate technology capable of upgrading the current satellite early warning system. This experiment will, if successful, also permit a decision to be made on the applicability of more advanced technology for ABM purposes. The BSTS experimental device will not be a prototype of an ABM component. The BSTS experimental device will be limited in capability so that it cannot substitute for an ABM component, but will be capable of performing early warning functions. For example, the experimental devices may measure the signatures of booster plumes, but not in real time. Other capabiliites may be limited as well. (Category 2)

The space-based Space Surveillance and Tracking System Experiment (which is not fully defined) is to demonstrate technology capable of upgrading the current space surveillance assets and will also permit a decision to be made on the applicability of more advanced technology for ABM purposes. This experiment will demonstrate the collection of tracking and signature data on a number of space objects. The capabilites of any demonstration satellites will be significantly less than those necessary to achieve ABM performance levels or substitute for an ABM component. (Category 2)

The Airborne Optical Adjunct (AOA) Experiment will demonstrate the technical feasibility of using optical sensors on an airborne platform (late 1980s). The AOA experimental device (a passive sensor) will not be capable of substituting for an ABM component due to sensor and platform limitations. As part of the feasibility demonstration, the AOA experimental device is to observe ballistic missile tests at agreed ABM Test Ranges. (Category 2)

The purpose of the space-based Kinetic Kill Vehicle project (which is not fully defined) is to prove the feasibility of rocket propelled projectile launch and guidance. This experiment will, if successful, demonstrate a capability to defend against anti-satellite interceptors and will also permit a decision to be made on the applicability of more advanced technology for ABM purposes. The demonstration hardware will not be an ABM component, will not be "capable of substituting for an ABM component" and will not be "tested in an ABM mode". To ensure compliance with the ABM Treaty the performance of the demonstration hardware will be limited to the satellite defense mission. Intercepts of certain orbital targets simulating anti-satellite weapons can clearly be compatible with this criteria. Intercepts of strategic ballistic missiles or their elements in flight would clearly not be permitted. (Category 2)

The Ground-Based Railgun Experiment (which is not fully defined) is intended to validate the potential of devices of this type. Several types of projectiles will be fabricated to demonstrate that they can be successfully launched from these guns. The test devices will not be ABM components and will not have ABM capabilities. They will demonstrate the capability to launch unguided and guided projectiles and will not involve "testing in an ABM mode". (Category 1)

The space-based Railgun Experiment (which is not fully defined) will demonstrate space-based operation of a railgun device. In addition to showing that devices of this type can operate in space, these experiments will demonstrate guidance and control of projectiles. This experiment will, if successful, demonstrate a capability to defend against anti-satellite interceptors and will also permit a decision to be made on the applicability of more advanced technology for ABM purposes. Specific performance parameters for the experiments will be established to satisfy Treaty compliant guidelines. (Cateogry 2)

Category 3 Experiments. Five of the planned experiments involve tests of fixed ground-based "ABM components" at an identified ABM Test Range.

The High Endoatmospheric Defense Interceptor (HEDI) project is to demonstrate the capability to intercept and negate strategic ballistic missile warheads within the atmosphere. This is an allowed test of a nonnuclear interceptor missile. Flight tests will be performed at agreed test ranges. All flight tests will be from fixed ground-based launchers without the capability of being rapidly reloaded or launching more than one interceptor missile. The interceptor missiles will not be capable of delivering more than one independently targetable warhead. All activity will be conducted in a manner permitted by the ABM Treaty. (Category 3)

The Exoatmospheric Reentry-Vehicle (RV) Interceptor Subsystem (ERIS) is intended to engage incoming RVs above the atmosphere. This is an allowed test of a nonnuclear interceptor missile. All interceptor missile flight tests are to be conducted from fixed ground-based launchers at agreed test ranges. The planned flight tests include missile integrity launches and various homing and intercept flights with and without targets. Fixed ground-based launchers will be incapable of launching more than one interceptor missile and will not be rapidly reloadable. The ERIS interceptor missile will

not be capable of delivering more than one independently targetable warhead. (Category 3)

The Terminal Imaging Radar (TIR) will be an ABM radar "tested in the ABM mode" in full compliance with the terms of the ABM Treaty. It will be tested at a designated ABM test range from a fixed, land-based platform. TIR will be permanently installed in an existing radar building and will require this building for structural support. TIR will perform target pre-commit discrimination and handover to the interceptor missiles. (Category 3)

The Long Wavelength Infrared (LWIR) Probe is planned to use a ground-launched, LWIR sensor in a feasibility demonstration experiment. All tests will be conducted from a fixed, land-based launcher at an agreed test range. If LWIR Probe (after it is better defined) is considered an ABM component, it must be fixed, land-based and be tested only at agreed test ranges. (Category 3)

The integrated demonstration will validate the integrated capability of the Terminal Imaging Radar, High Endoatmospheric Nonnuclear Interceptor, and associated Command, Control, and Communications systems to perform terminal defense engagements. In this demonstration, strategic ballistic missiles will be intercepted in flight. This is permitted under the Treaty provided that the "ABM components" are fixed, land-based and provided that multiple launch, rapidly reloadable and independently guided warhead restrictions are met. Flight tests of ABM interceptor missiles are to be conducted at agreed test ranges from fixed ground-based launchers. (Category 3)

APPENDIX C

THE STRATEGIC DEFENSE INITIATIVE (SDI) AND OTHER STRATEGIC DEFENSE ACTIVITIES

C.1 SOVIET STRATEGIC DEFENSIVE CAPABILITIES

C.1.1 CONGRESSIONAL REPORTING REQUIREMENTS

The following deals with the Congressional requirement for a report on "...the current and future responsibilities of Soviet strategic defense forces, including ballistic missiles, space and air defense systems (including space-based and directed energy weapons and components), strategic antisubmarine warfare, internal defense and civil defense measures, and the political, military, strategic and budgetary implications of these forces for the United States and its Allies."

C.1.2 IMPLICATIONS OF SOVIET DEFENSIVE MEASURES

The implications of Soviet defensive measures for the viability of U.S. and Allied deterrent capability are great. With an extensive Soviet air and civil defense capability already in existence--a capability that is continually being upgraded, both quantitatively and qualitatively—and an extensive program to harden their ICBM silos (far above the strength of Minuteman silos), launch facilities and key C^3 and leadership bunkers, the Soviets are well on their way toward establishing a credible active and passive defense capability. These developments are particularly meaningful when viewed in conjunction with the extensive Soviet build-up of modern, accurate ballistic missiles of both intercontinental and shorter-range that are being deployed in numbers sufficient to convey a first-strike capability. It is to redress the imbalance created by these Soviet efforts that the U.S. is pursuing its strategic- and intermediate-range modernization programs.

The Soviet Union has long maintained an extensive ballistic missile defense research, development and deployment program. This program includes: new ABM deployments near Moscow including deployment of improved long-range and new short-range interceptor missiles and a new sophisticated radar; development of components for a new ABM system, designed to be deployable at sites requiring little or no preparation, and that could support a breakout from the ABM Treaty should the Soviets choose to do so; development of a new air defense missile system, the SA-X-12, which is both a tactical surface-to-air missile (SAM) and an antitactical ballistic missile and which may have the potential to intercept some types of intercontinental-range ballistic missiles; and research and development on advanced weapons technologies--such as lasers and neutral particle beams—with application to ballistic missile defense, as well as antisatellite systems.

If the Soviet Union were to develop and deploy an effective defense against ballistic missiles, in conjunction with its continually improving air and civil defenses, and if the U.S. and its Allies did not have similar options to exercise in response, deterrence of Soviet aggression would be very seriously underminded. This point is too clear to require elaboration.

Because of the importance that Soviet doctrine attaches to defensive forces and the fact that arms control cannot necessarily be seen as a useful means of diverting Soviet effort away from further work on ballistic missile defense, it is essential, at the very least, that the U.S. conduct an extensive research program into the potential of advanced technologies to negate the military effectivenss of ballistic missiles. Failure to do so will submit the United States and its Allies to the adverse consequences of a critical emerging deterrence imbalance.

The budgetary implications of the Soviet efforts depend significantly on whether and when the Soviet Union might decide to exploit the advances being made as a result of its research and development programs. However, for the near term, the budgetary implications are limited primarily to the expenditure the U.S. plans to make on the SDI research program over the next several years and those on-going expenditures associated with the U.S. program that are designed to maintain the effectiveness of the strategic Triad. The new expenditures associated with the SDI program are expected to amount to approximately $26 billion over the next five years. This spending will not affect funding for the strategic and intermediate nuclear forces and the conventional forces to the maintenance of an effective deterrent.

For the longer term, in the event the U.S. and its Allies, and the Soviet Union were to decide to begin to deploy defenses against ballistic missiles, cost savings from otherwise necessary ballistic missile forces' modernization in the next century could help offset the cost of ballistic missile defense deployments. Also, to the extent that meaningful reductions in ballistic missile forces can be achieved, total ballistic missile defense costs could be reduced.

The most recent unclassified description of Soviet strategic defense and space programs is to be found in Chapter III of <u>Soviet Military Power</u> (U.S. Government Printing Office, 1985), and is repeated here for the reader's convenience.

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Excerpt from <u>Soviet Military Power</u>, 1985
Concerning Soviet Strategic Defense and Space Capabilities

Chapter III
Strategic Defense and Space Programs

Strategic defenses are vital to the overall Soviet strategy for nuclear war. The operations of Soviet defensive and attack forces, as noted in Chapter II, are closely coupled; attack strategies are geared in large part to the reduction of the defensive burden. In the Soviet concept of a layered defense, effectiveness is achieved through multiple types of defensive capabilities compensating for shortcomings in individual systems and for the likelihood that neither offensive strikes nor any one layer of defense will stop all attacking weapons. The Soviets are making major improvements in their deployed strategic defenses and are investing heavily in ABM-related developments.

Soviet Military Power 1983 and 1984 outlined the continuing expansion into space of the Soviet drive for military superiority. In the past year, some 80 percent of Soviet space launches have been purely military in nature, with much of the remainder serving both military and civil functions. This is an increase from 70 percent in previous years. The Soviet military space program dominates the USSR's overall space effort. Soviet military doctrine establishes requirements for the military space program.

Laser/Energy Weapons Systems

Soviet directed-energy development programs involve future Ballistic Missile Defense (BMD) as well as antisatellite and air-defense weapons concepts.

By the late 1980s, the Soviets could have prototypes for ground-based lasers for ballistic missile defense. Testing of the components for a large-scale deployment system could begin in the early 1990s. The many difficulties in fielding an operational system will require much development time, and initial operational deployment is not likely in this century. However, with high priority and some significant risk of failure, the Soviets could skip some testing steps and be ready to deploy a ground-based laser BMD by the early-to-mid-1990s.

Ground- and space-based particle beam weapons for ballistic missile defense will be more difficult to develop than lasers. Nevertheless, the Soviets have a vigorous program underway for particle beam development and could have a prototype space-based system ready for testing in the late 1990s.

The Soviets have begun to develop at least three types of high-energy laser weapons for air defense. These include lasers intended for defense of high-value strategic targets in the USSR, for point defense of ships at sea, and for air defense of theater forces. Following past practice, they are likely to deploy air defense lasers to complement, rather than replace, interceptors and surface-to-air missiles (SAMs). The strategic defense laser is probably in at least the prototype stage of development and could be operational by the late 1980s. It most likely will be deployed in conjunction with SAMs in a point defense role. Since the SAM and laser systems would have somewhat different attributes and vulnerabilities, they would provide mutual support. The shipborne lasers probably will not be operational until after the end of the decade. The theater force lasers may be operational sometime sooner and are likely to be capable of structurally damaging aircraft at close ranges and producing electro-optical and eye damage at greater distances.

The Soviets are also developing an airborne laser. Assuming a successful development effort, limited initial deployment could begin in the early 1990s. Such a laser platform could have missions including antisatellite operations, protection of high-value airborne assets, and cruise missile defense.

The Soviets are working on technologies or have specific weapons-related programs underway for more advanced antisatellite systems. These include

space-based kinetic energy, ground- and space-based laser, particle beam, and radiofrequency weapons. The Soviets apparently believe that these techniques offer greater promise for future antisatellite application than continued development of ground-based orbital interceptors equipped with conventional warheads. The Soviets also believe that military applications of directed-energy technologies hold promise of overcoming weaknesses in their conventional air and missile defenses.

The USSR's high-energy laser program, which dates from the mid-1960s, is much larger than the US effort. They have built over a half-dozen major R&D facilities and test ranges, and they have over 10,000 scientists and engineers associated with laser development. They are developing chemical lasers and have continued to work on other high-energy lasers having potential weapons applications--the gas dynamic laser and the electric discharge laser. They are also pursuing related laser weapon technologies, such as efficient electrical power sources, and are pursuing capabilities to produce high-quality optical components. They have developed a rocket-driven magnetohydrodynamic (MHD) generator which produces 15 megawatts of short-term electric power--a device that has no counterpart in the West. The scope of the USSR's military capabilities would depend on its success in developing advanced weapons, including laser weapons for ballistic missile defense.

The Soviets have now progressed beyond technology research, in some cases to the development of prototype laser weapons. They already have ground-based lasers that could be used to interfere with US satellites. In the late 1980s, they could have prototype space-based laser weapons for use against satellites. In addition, ongoing Soviet programs have progressed to the point where they could include construction of ground-based laser antisatellite (ASAT) facilities at operational sites. These could be available by the end of the 1980s and would greatly increase the Soviets' laser ASAT capability beyond that currently at their test site at Sary Shagan. They may deploy operational systems of space-based lasers for antisatellite purposes in the 1990s, if their technology developments prove successful, and they can be expected to pursue development of space-based laser systems for ballistic missile defense for possible deployments after the year 2000.

Since the early 1970s, the Soviets have had a research program to explore the technical feasibility of a particle beam weapon in space. A prototype space-based particle beam weapon intended only to disrupt satellite electronic equipment could be tested in the early 1990s. One designed to destroy satellites could be tested in space in the mid-1990s.

The Soviets have conducted research in the use of strong radiofrequency (RF) signals that have the potential to interfere with or destroy components of missiles, satellites, and reentry vehicles. In the 1990s, the Soviets could test a ground-based RF weapon capable of damaging satellites.

Soviet programs for the development and application of directed energy technologies to strategic defense have been very vigorous in the past and will continue to be so in the future, irrespective of what the US does about new strategic defense initiatives.

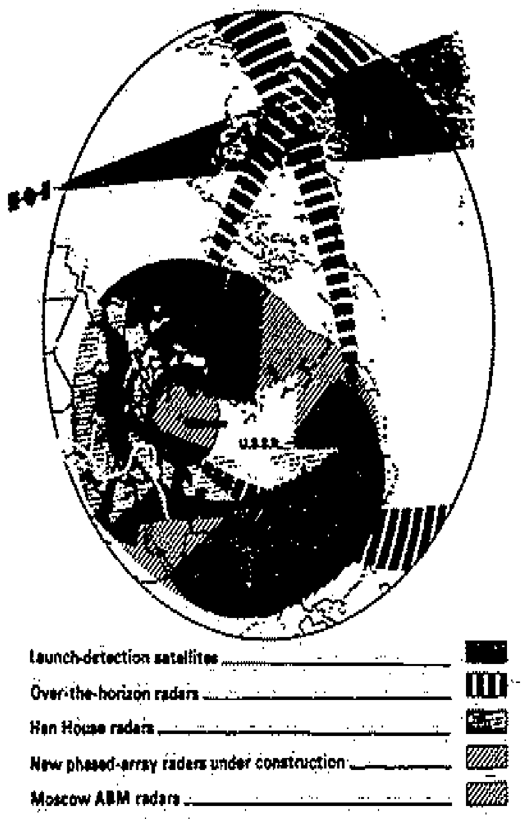
In the area of kinetic energy weapons, using the high-speed collision of a small mass with the target as the kill mechanism, the Soviets have a variety of research programs underway. These programs could result in a near-term, short-range, space-based system useful for satellite or space station defense or for close-in attack by a maneuvering satellite. Longer range, space-based systems probably could not be developed until the mid-1990s or even later.

Early Warning

The Soviets maintain the world's most extensive early warning system for both ballistic missile and air defense. Their operational ballistic missile early warning system includes a launch-detection satellite network, over-the-horizon radar, and a series of large phased-array radars located primarily on the periphery of the USSR. Their early warning air surveillance system is composed of an extensive network of ground-based radars linked operationally with those of their Warsaw Pact allies.

The current Soviet launch-detection satellite network is capable of providing about 30 minutes warning of any US ICBM launch and of determining the general area from which it originated. The two over-the-horizon radars the Soviets have directed at the US ICBM fields also could provide them with 30 minutes warning of an ICBM strike launched from the United States, but with somewhat less precision than the satellite network. Working together, these two early warning systems can provide more reliable warning than either working alone.

Coverage of Ballistic Missile Detection and Tracking Systems



The next layer of operational ballistic missile early warning consists of 11 large HEN HOUSE detection and tracking radars at six locations on the periphery of the USSR. These radars can distinguish the size of an attack, confirm the warning from the satellite and over-the-horizon radar systems, and provide target-tracking data in support of antiballistic missile (ABM) deployments.

Current Soviet air surveillance radar deployments include more than 7,000 radars of various types located at about 1,200 sites. These deployments provide virtually complete coverage at medium-to-high altitudes over the USSR and in some areas extend hundreds of kilometers beyond the borders. Moreover, the over-the-horizon radars provide additional warning of the approach of high-flying aircraft. Limited coverage against low-altitude targets is concentrated in the western USSR and in high-priority areas elsewhere. Since 1983, the Soviets have begun to deploy two new types of air surveillance radars. These radars assist in the early warning of cruise missile and bomber attacks and enhance air defense electronic warfare capabilities.

The new large phased-array radar for ballistic missile early warning and target-tracking discovered in 1983 in Siberia is still under construction. This new radar closes the final gap in the combined HEN HOUSE and new large phased-array radar early warning and tracking network. Together, this radar and the five others like it form an arc of coverage from the Kola Peninsula in the northwest, around Siberia, to the Caucasus in the southwest. The new radar violates the 1972 ABM Treaty in that it is not located on the periphery of the Soviet Union, nor is it pointed outward as required by the Treaty. Its orientation and function indicate it is for ballistic missile detection and tracking—not space object tracking as claimed by the Soviets. The complete network of these radars, which could provide target-tracking data for ABM deployments beyond Moscow, probably will be operational by the late 1980s.

The Soviets may establish a network of satellites in geostationary orbit designed to provide timely indications of ballistic missiles, including submarine-launched ballistic missile (SLBM) launches. Such a network could be operational by the end of the decade.

The USSR has a strong research and development program to produce new early warning and other air surveillance radars as well as to improve existing systems. More than 15 types of these radars are currently in development. In addition, the Soviets are continuing to deploy improved air surveillance data systems that can rapidly pass data from outlying radars through the air surveillance network to ground-controlled intercept sites and SAM command posts. These systems will continue to be deployed until all areas are equipped with them.

Ballistic Missile Defense

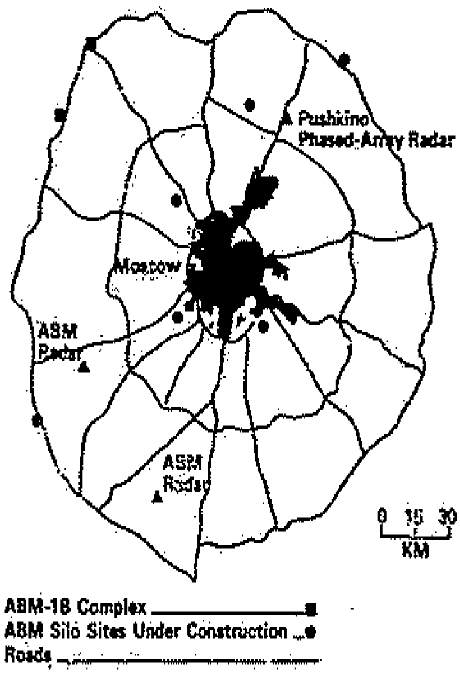
The Soviets are continuing a major upgrading of their ballistic missile defense capabilities. The Moscow missile defenses are being enlarged and equipped with a new generation of radars and interceptor missiles. Developments aimed at providing the foundation for widespread ABM deployments beyond Moscow are underway.

The new SA-X-12 surface-to-air missile, which incorporates ballistic missile defense capabilities, is nearing operational status, while research on directed-energy BMD technology continues apace.

The Soviets maintain around Moscow the world's only operational ABM system. This system is intended to afford a layer of defense for Soviet civil and military command authorities in the Moscow area during a nuclear war rather than blanket protection for the city itself. Since 1980, the Soviets have been upgrading and expanding this system around Moscow within the limits of the 1972 ABM Treaty.

The original single-layer Moscow ABM system included 64 reloadable above-ground launchers at four complexes for the GALOSH ABM-1B, six TRY ADD guidance and engagement radars at each complex, and the DOG HOUSE and CAT HOUSE target-tracking radars south of Moscow. The Soviets are upgrading this system to the 100 accountable launchers permitted under the ABM Treaty. When completed, the new system will be a two-layer defense composed of silo-based, long-range, modified GALOSH interceptors designed to engage targets outside the atmosphere; silo-based high-acceleration interceptors designed to engage targets within the atmosphere; associated engagement and guidance radars; and a new large radar at Pushkino designed to control ABM engagements. The silo-based launchers may be reloadable. The first new launchers are likely to be operational this year, and the new defenses could be fully operational by 1987.

Moscow Ballistic Missile Defense



The Soviets are developing a rapidly deployable ABM system to protect important target areas in the USSR. They have been testing all the types of ABM missiles and radars needed for widespread ABM defenses beyond the 100 launcher limit of the 1972 ABM Treaty. Within the next 10 years, the Soviets could deploy such a system at sites that could be built in months instead of years. A typical site would consist of engagement radars, guidance radars, above-ground launchers, and the high-acceleration interceptor. The new, large phased-array radars under construction in the USSR, along with the HEN HOUSE, DOG HOUSE, CAT HOUSE, and possibly the Pushkino radar, appear to be designed to provide support for such a widespread ABM defense system. The aggregate of the USSR's ABM and ABM-related activities suggests that the USSR may be preparing an ABM defense of its national territory.

In addition, the Soviets are deploying one surface-to-air missile system, the SA-10, and are flight testing another, the mobile SA-X-12. The SA-X-12 is both a tactical SAM and antitactical ballistic missile. It may have the capability to engage the LANCE and both the PERSHING I and PERSHING II ballistic missiles. The SA-10 and SA-X-12 may have the potential to intercept some types of US strategic ballistic missiles as well. These systems could, if properly supported, add significant point-target coverage to a widespread ABM deployment.

Air Defense

The Soviets have deployed numerous strategic and tactical air defense assets that have excellent capabilities against aircraft flying at medium and high altitudes. Although their capability to intercept low-flying penetrators is marginal, they are in the midst of a major overhaul geared toward fielding an integrated air defense system much more capable of low-altitude operations. This overhaul includes partial integration of strategic and tactical air defenses; the upgrading of early warning and surveillance capabilities; the deployment of more efficient data transmission systems; and the development and initial deployment of new aircraft, associated air-to-air missiles, surface-to-air missiles, and airborne warning and control system (AWACS) aircraft.

Over the years, the Soviets have invested enormous resources in their air defense systems. This sustained effort has produced an array of weapons systems designed for a variety of air defense applications. For example, they have fielded 13 different surface-to-air missile systems, each designed to cover a specific threat regime.

The Soviets have made significant shifts in the subordination of their air and air defense assets. The reorganization has resulted in a streamlined organization that merged strategic and tactical air and air defense assets in most land border areas of the USSR. The air defense (APVO) interceptors became part of a new structure, the Air Forces of the Military District (MD), which also includes most of the assets of the former tactical air armies. The Air Forces of an MD include all air assets in their geographic area (excluding Strategic Aviation and transport assets). These assets can be used either offensively or defensively as the situation requires. The new structure improves defensive capabilities, but its most significant impact is on the capability to conduct massed offensive air operations. Technological

advances in weapons systems and in command, control, and communications have made its implementation possible.

In terms of numbers alone, Soviet strategic and tactical air defense forces are impressive. Moreover, with the continuing deployment of new systems like the SA-10 SAM and impending deployment of the SA-X-12, these numbers are increasing along with capability. Currently, the Soviets have nearly 10,000 SAM launchers at over 1,200 sites for strategic defense, along with more than 4,000 launch vehicles for tactical SAMs, subordinated to nearly 445 launch units. More than 1,200 interceptors are dedicated to strategic defense, while an additional 2,800 Soviet Air Forces (SAF) interceptors could also be used. Further, the Soviets are continuing the MAINSTAY AWACS aircraft program and test and evaluation is underway. The MAINSTAY will substantially improve Soviet capabilities for early warning and air combat command and control, especially against low-flying aircraft. The MAINSTAY will also provide Soviet air defenses with overland and overwater capabilities to detect aircraft and cruise missile targets flying at low altitudes. Additionally, the MAINSTAY could be used to help direct fighter operations over European and Asian battlefields and to enhance air surveillance and defense of the USSR. MAINSTAY production could be about five aircraft per year.

The 1,200 all-weather interceptors assigned to strategic defense are primarily based in central air defense regions of the Soviet Union, in addition to fighter/interceptors subordinate to the military districts that are generally located on the periphery of the Soviet Union. The interceptor force is composed of a wide variety of aircraft with varying capabilities.

The deployment of the supersonic MiG-31/FOXHOUND interceptor, the first Soviet aircraft with a true look-down/shoot-down and multiple-target engagement capability, continued during 1984. The FOXHOUND, comparable in size to the US F-14 TOMCAT, is deployed at several locations from the Arkhangelsk area to the Far East Military District. More than 70 of these aircraft are operational.

The MiG-25/FOXBAT A/E is a high-altitude, high-speed interceptor that comprises approximately one-quarter of the strategic interceptor force. The upgrade program of the FOXBAT A to the newer FOXBAT E configuration provides a limited look-down radar capability. The remaining FOXBAT A aircraft are expected to be modified to the FOXBAT E configuration during 1985.

The MiG-23/FLOGGER B/G fighter comprises approximately one-third of the total strategic interceptor forces. This valuable geometry-wing fighter is equipped with a limited look-down radar. The remaining aircraft employed as interceptors (the older FLAGON, FIDDLER, and FIREBAR) comprise less than one-third of the force.

Two new fighter-interceptors, the Su-27/FLANKER and the MiG-29/FULCRUM, have true look-down/shoot-down capabilities. The FULCRUM is a single-seat, twin-engine fighter similar in size to the US F-16. First deployments of the FULCRUM to the Soviet Air Force military districts have begun, and more than 30 are now operational. The FLANKER is a larger, single-seat, twin-engine fighter similar in size to the US F-15. Both aircraft have been designed to be highly maneuverable in air-to-air combat.

The three latest Soviet fighter-interceptor aircraft are equipped with two new air-to-air missiles, the AA-9 designed for the FOXHOUND and the AA-10 designed for the FULCRUM and the FLANKER. The AA-9 is a long-range missile that can be used against low-flying targets; the AA-10 is a medium-range missile with similar capabilities.

The FLANKER and the FULCRUM, as well as the FOXHOUND, are likely to operate under certain circumstances with the new MAINSTAY AWACS aircraft.

Soviet strategic SAMs form barrier, area, and terminal defenses. They afford broad coverage for medium- and high-altitude defenses under all weather conditions. Five systems are operational--the SA-1, SA-2, SA-3, SA-5, and SA-10. Of these, only the SA-10 is capable of defending against targets with a small radar-cross-section such as cruise missiles.

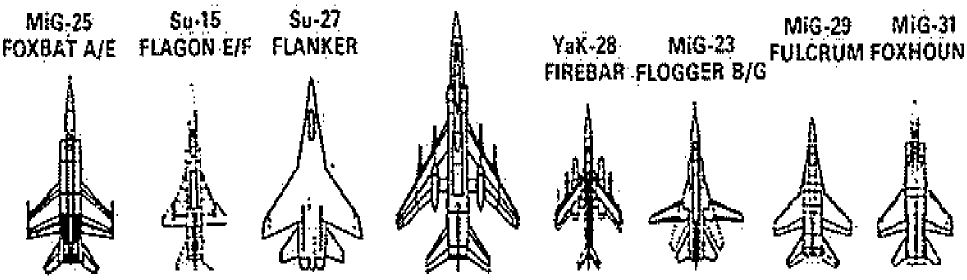
The first SA-10 site reached operational status in 1980. Nearly 60 sites are now operational and work is underway on at least another 30. More than half of these sites are located near Moscow. This emphasis on Moscow and the patterns noted for the other SA-10 sites suggest a first priority on terminal defense of wartime command and control, military, and key industrial complexes. Over the years, the Soviets have continued to deploy the long-range SA-5 and have modified the system repeatedly. Further deployment and upgrading of the SA-5 to enhance its capability to work in conjunction with low-altitude systems like the SA-10 are likely in the future.

In keeping with their drive toward mobility as a means of weapons survival, the Soviets are developing a mobile version of the SA-10 SAM. This mobile version could be used to support Soviet theater forces but, perhaps more importantly, if deployed with the territorial defense forces, it would allow the Soviets to change the location of SA-10 sites in the USSR. The mobile SA-10 could be operational sometime this year.

The 1980 air defense reorganization permits efficient integration of strategic and tactical SAM systems. Most tactical SAMs are not as range-capable as strategic SAMs, but many have better low-altitude capabilities.

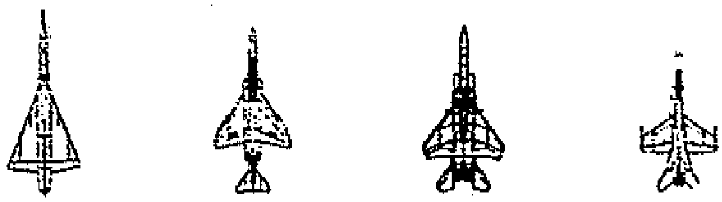
A mixed and integrated system of aircraft, SAMs, and antiaircraft artillery (AAA) provides the Soviet Union with the most comprehensive air defense system in the world. Over 4,600 SAM launcher vehicles and 11,500 AAA pieces are deployed at regimental through front level. In addition, as many as 25,000 shoulder-fired SAM launchers are found at battalion and company level and with non-divisional units. The standard air defense for a tank or motorized rifle regiment is a battery of SA-9/13 SAMs and ZSU-23/4 self-propelled AAA pieces. The SA-9 system, mounted on a wheeled transporter-erector-launcher (TEL), is being replaced by the SA-13 on a tracked TEL. A follow-on to the ZSU-23/4 is expected shortly. The standard SAM at division level is the SA-6 or SA-8, although some divisions still have an AAA-equipped air defense regiment. A new division-level SAM, the SA-11, is beginning to enter the inventory. It features an onboard radar that increases mobility and target-handling capability. The standard weapon at army and front levels is the SA-4, soon to be replaced by the SA-X-12. The SA-X-12 has good low-altitude air defense capabilities as well as the ballistic missile defense

USSR Air Defense Interceptor Aircraft



	MiG-25 FOXBAT A/E	Su-15 FLAGON E/F	Su-27 FLANKER	Tu-128 FIDDLER B	YaK-28 FIREBAR	MiG-23 FLOGGER B/G	MiG-29 FULCRUM	MiG-31 FOXHOUND
SPEED (KTS)	1,625	1,200	1,350	550	1,080	1,350	1,350	1,375
RADIUS (KM)	1,450	1,000	1,500	1,500	900	1,300	1,150	2,100
ARMAMENT	4 AAMs	2 AAMs	6 AAMs	4 AAMs	2 AAMs	6 AAMs	6 AAMs	8 AAMs
WINGSPAN (M)	14	9	14	18	12	8 (swept)	12	14

North American Air Defense Interceptor Aircraft



	F-106A DELTA DART	F-4C/D PHANTOM II	F-15A EAGLE	CF-18* HORNET
SPEED (KTS)	1,150	1,200	1,450	1,040
RADIUS (KM)	925	825	1,000	740
ARMAMENT	5 AAMs	8 AAMs	8 AAMs	6 AAMs
WINGSPAN (M)	12	12	13	12

*Canadian

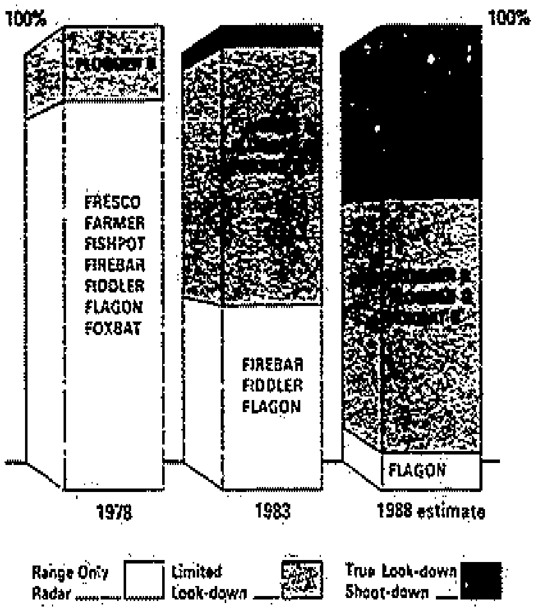
Soviet Territorial Air Defense

Interceptor Aircraft Bases

Strategic SAM Concentrations

Radars (BMD EW, OTH types)

Interceptor Aircraft Radar Capability



capabilities noted above. Soviet tactical SAM development is both broad-based and active. New tactical SAMs and improvements to older ones are now under development.

The largest concentration of SAM launchers and AAA pieces--over 8,100--is found opposite European NATO; over 4,200 are opposite the Sino-Soviet border and in the Far East; there are nearly 700 opposite southwest Asia and eastern Turkey; over 1,300 are in the Strategic Reserve military districts.

Passive Defense

Soviet passive defense preparations have been underway in earnest for some 30 years and have, over time, expanded from the protection of such vital entities as the national Party and government leadership and Armed Forces to embrace the territorial leadership, national economy, and general population. The Soviets regard passive defense as an essential ingredient of their overall military posture and war planning. In conjunction with active forces, the Soviets plan for a passive defense program to ensure the survival and wartime continuity of:

- Soviet leadership;
- military command and control entities;
- war-supporting industrial production and services;
- the essential workforce; and
- as much of the general population as possible.

As this program has expanded, elements of it have been designated by the Soviets as "civil defense." Use of this term in its normal Western context does not convey the full scope of Soviet Civil Defense.

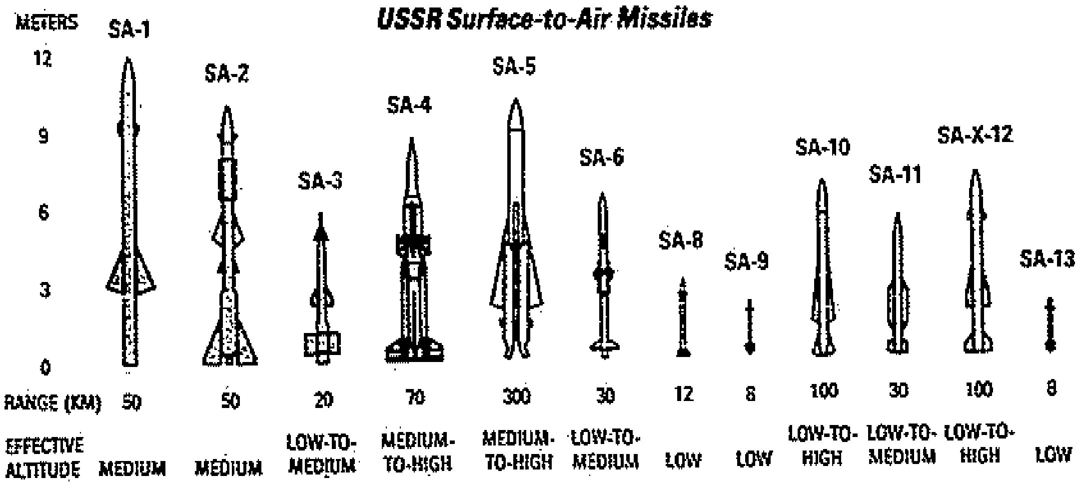
Extensive planning for the transition of the entire State and economy to a wartime posture has been fundamental to Soviet passive defense preparations. The Soviet General Staff and Civil Defense officials have supervised the development of special organizations and procedures to implement a rapid transition to war and have emphasized the mobilization and protection of all national resources essential to the successful prosecution of war and recovery.

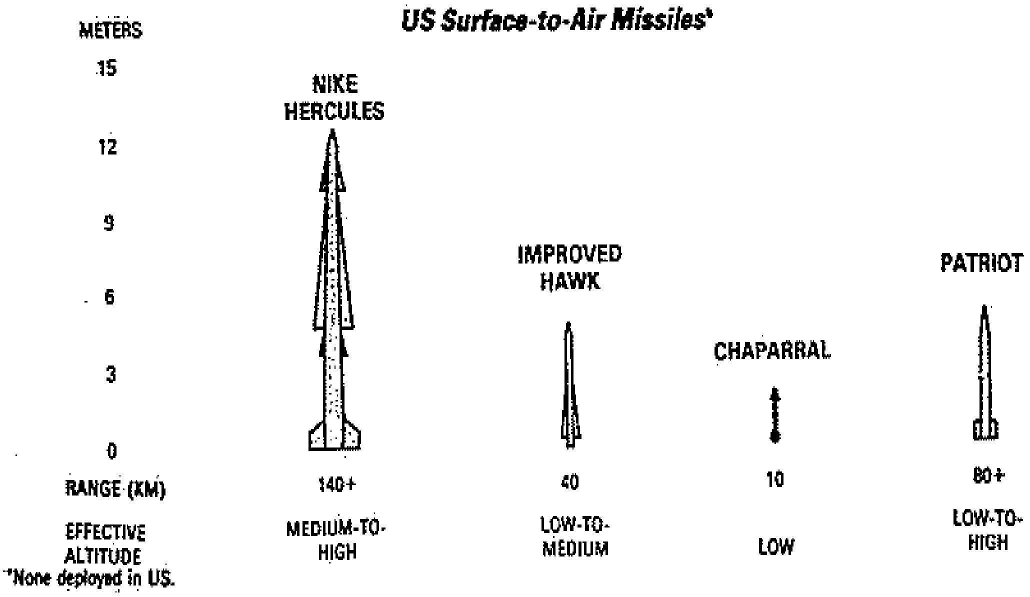
The senior Soviet military establishment has also supervised the 30-year program to construct hardened command posts and survivable communications for key military commanders and civilian managers at all levels of the Party and government. Likewise, protective hardening, dispersal, and wartime production plans for Soviet industry have all been coordinated with the wartime requirements of the military and supervised by Civil Defense personnel. The protection of the general population through evacuation procedures and extensive sheltering in or near urban areas is the most visible aspect of the passive defense program.

The passive defense program reflects the Soviets' belief of their wartime need. The wartime management system would be the militarized system of national administration in which peacetime government bodies become Civil Defense components under direct military subordination. This would extend to Soviet territorial administration at all levels and to specialized functional components such as industrial, transport, power, communications ministries.

Soviet authorities at all levels would serve as uniformed chiefs of Civil Defense and command their respective organizations in a military capacity. Soviet Civil Defense thus serves both as a vehicle to administer peacetime preparations and training and as the infrastructure that would keep together civil and military bodies in the unified wartime management systems.

Soviet commanders and managers at all levels of the Party and government are provided hardened alternate command posts located well away from urban centers. This comprehensive and redundant system, composed of more than 1,500 hardened facilities with special communications, is patterned after similar capabilities afforded the Armed Forces. More than 175,000 key personnel throughout the system are believed to be equipped with such alternate facilities in addition to the many deep bunkers and blast shelters in Soviet cities.





Soviet passive defense efforts include measures to maintain essential production and services even during a nuclear war. Elaborate plans have been set for the full mobilization of the national economy in support of the war effort and the conversion to wartime production. Reserves of vital materials are maintained, many in hardened underground structures. Redundant industrial facilities have been built and are in active production. Industrial and other economic facilities have been equipped with blast shelters for the workforce, and detailed procedures have been developed for the relocation of selected plants and equipment. By ensuring the survival of essential workers, the Soviets intend to reconstitute vital production programs using those industrial components that can be redirected or salvaged after an attack.

The annual military and civilian cost of four elements of the program--pay and allowances for full-time Civil Defense personnel; operation of specialized military Civil Defense units; construction and maintenance of facilities for these units; and shelter construction—is less than 1 percent of the estimated Soviet defense budget. If duplicated in the United States, these four elements would cost roughly $3 billion annually. The cost of construction and equipment for leadership relocation sites over the past 25 years is between 8 and 16 billion rubles, or $28-56 billion if acquired in the United States.

North American Defense Forces

United States and Canadian interceptor forces assigned to the North American Aerospace Defense Command (NORAD) maintain continuous ground alert at sites around the periphery of the United States and Canada. Alert aircraft intercept and identify unknown intruders. At present, there are no SAMs for US continental air defense. In a crisis, the Air Force, Navy, and Marine Corps could provide additional interceptors. Supported by AWACS aircraft, these forces could provide a limited defense against bomber attacks.

To meet the increasing Soviet bomber and air-launched cruise missile (ALCM) threats, US interceptor squadrons assigned to NORAD are being equipped with newer more advanced F-15 and F-16 aircraft. These modern fighters will provide a look-down/shoot-down capability to detect and engage enemy bombers penetrating at low altitudes. The Canadians are upgrading their air defense forces with the CF-18. Joint United States and Canadian improvements to long-range surveillance include modern microwave radars for the Distant Early Warning line and over-the-horizon back-scatter radars looking east, west, and south.

Soviet space-oriented military systems pose a threat to the land, sea, and air forces of the United States. Some Soviet satellites are designed to support targeting of Soviet antiship cruise missiles launched against US surface ships. The US ASAT program, centering on the Air-Launched Miniature Vehicle, is part of the response to this and similar threats.

Finally, the United States has called for a research program to explore the possibility of strengthening deterrence by taking advantage of recent advances in technology that could, in the long term, provide an effective defense against ballistic missiles.

The Soviet Space Program

The Soviets believe in the combined arms concept of warfare in which all types of forces are integrated into military operations to achieve the desired goals. Space assets play a major role in this equation in the areas of antisatellite warfare; intelligence collection; command, control, and communications; meteorological support; navigational support; and targeting. The military support systems are linked to ground, naval, and air forces through earth terminals. Thus, Soviet forces can receive orders and information via satellite from command headquarters thousands of miles away. Their reliance on these systems is growing. Space weapons also play an important role in their strategic operations.

The late Marshal V. D. Sokolovskiiy included space in a statement defining the modern concept of a theater of military operations. The Soviet drive to use space for military purposes is an integral part of Soviet military planning. The Soviet coorbital ASAT system, while launched from the ground, is a space weapon system. The Soviets also have two ground-based lasers that are capable of attacking satellites in various orbits. These systems suggest that the Soviets are willing to use space for military purposes that are more ominous than those for which it has been used thus far.

The Soviets are currently developing a version of the US space shuttle, a heavy-lift booster system, a space plane, and directed-energy weapons and have engaged in military-related experiments aboard the SALYUT-7 space station. The Soviets continue to pursue their manned space programs, maintaining in orbit the SALYUT space station, which is manned during most of the year. This gives the Soviets the capability to perform a variety of functions from space, including military R&D and using man to augment their other reconnaissance and surveillance efforts. In addition, there are other developments indicating Soviet research on space-based ballistic missile defense.

Antisatelite Systems. Since 1971, the Soviets have had the capability to attack satellites in near-earth orbit with a ground-based orbital interceptor. Using a radar sensor and a pellet-type warhead, the interceptor can attack a target in various orbits during the interceptor's first two revolutions. An intercept during the first orbit would minimize the time available for a target satellite to take evasive action. The interceptor can reach targets orbiting at more than 5,000 kilometers, but it probably is intended for high-priority satellites at lower altitudes. The antisatellite interceptor is launched from Tyuratam, where launch pads and storage space for interceptors and launch vehicles are available. Several interceptors could be launched each day. In addition to the orbital interceptor, the Soviets have two ground-based, high-energy lasers with antisatellite capabilities. The Soviets also have the technological capability to conduct electronic warfare against space systems and could use their ABM interceptors in a direct-ascent attack on low-orbiting satellites.

Space Boosters. The Soviets currently maintain eight space launch systems that are used to place objects in orbits ranging from low-earth to geosynchronous and beyond. They are developing two more systems—a TITAN-Class medium-lift launch vehicle and a SATURN V-Class heavy-lift vehicle.

Also, they are developing their version of the US shuttle orbiter, which seems almost identical to its US counterpart, except for the absence of main engines. It is estimated that the new heavy-lift vehicles will be used to launch their orbiter as well as other large payloads. This vehicle should be able to lift as much as 150,000 kilograms to low-earth orbit, giving the USSR a tremendous capability to orbit heavy objects, such as the components for a large, manned space complex. The estimate for the medium-lift vehicle is a payload capacity of approximately 15,000 kilograms. This system may be used to launch their space plane, discussed below.

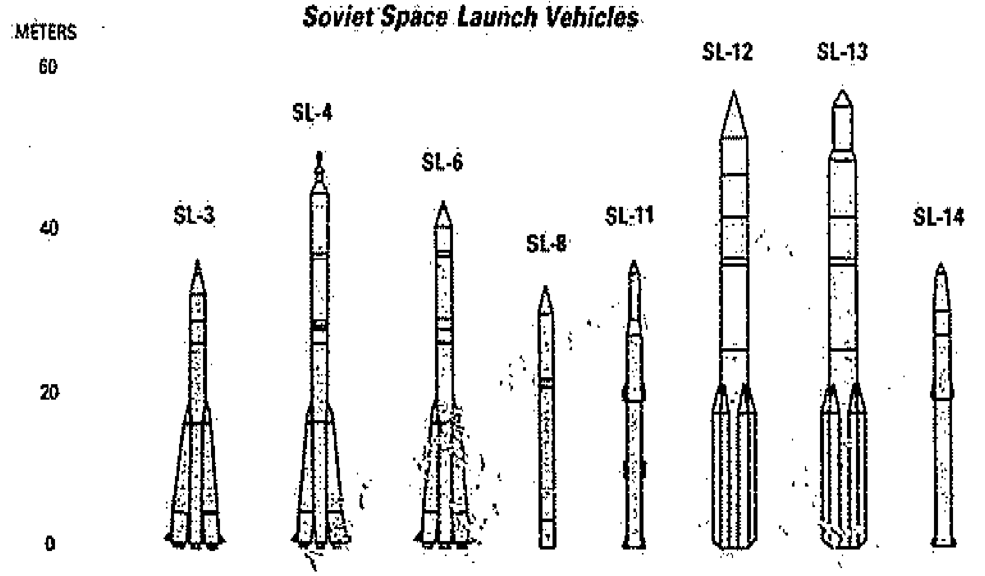
Manned Space Program. The Soviets have emphasized man in space since the beginning of their space program. In 1961 they placed the first man into orbit. Their SALYUT space stations have accommodated cosmonauts for extended periods, setting several records in the process. In 1984, three cosmonauts set a new record, spending 237 days aboard SALYUT 7. In 1982, two Soviet cosmonauts spent 211 days aboard the space station. At the end of 1984, Soviet cosmonauts had accumulated 3,691 man-days in space compared to the US astronauts total of 1,289. In the spring of 1984, Soviet cosmonauts demonstrated their capability to perform on-orbit maintenance and repair by conducting extra-vehicular activity (EVA) five times, gaining valuable experience in on-orbit repairs. During one EVA, the cosmonauts added new solar panels to SALYUT 7. During another EVA, the Soviets accomplished another space first—a space walk by a female cosmonaut, Svetlana Savitskaya.

The Soviets have made known their plans to replace SALYUT 7 with large space complexes, supporting 20 or more cosmonauts on a permanent basis. Such a complex will enhance their space-based military support and warfighting capabilities. Missions could include military R&D, on-orbit repair of satellites, reconnaissance, imagery interpretations, ASAT support operations, and ballistic missile defense support operations. Their shuttle orbiter will likely be used to ferry cosmonauts to this station as well as to place satellites in orbit.

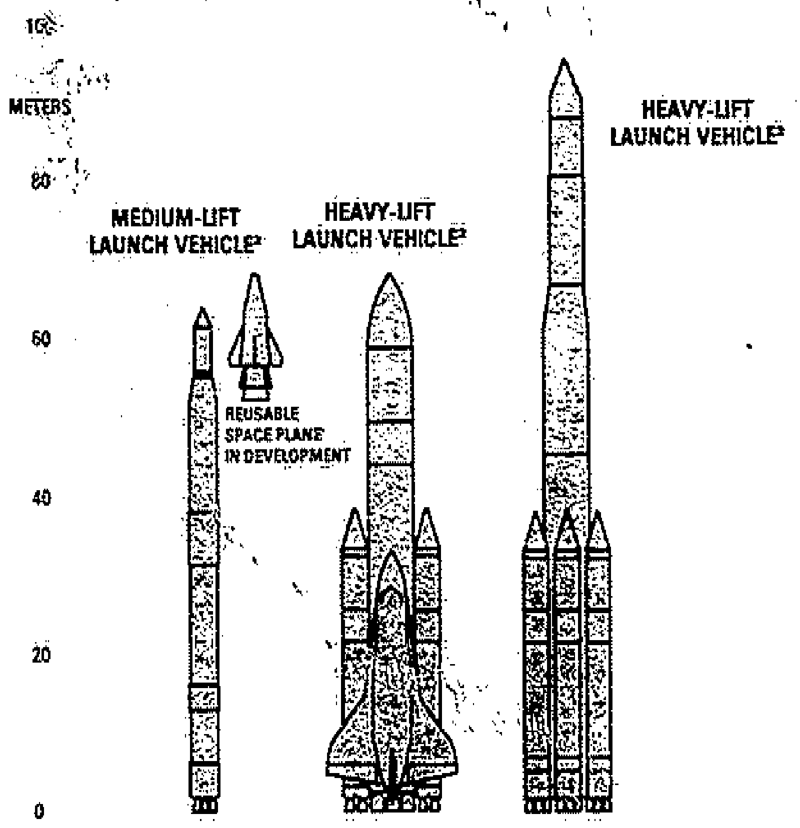
The Soviets apparently have already found some military utility in their manned space program. They have stated that "earth surface surveys" were conducted during past manned missions, but none of the photographs has ever been published. The combination of photographic and other missions aboard SALYUT 7 indicates the Soviets are aware of the potential value of manned space stations in an actual wartime situation.

The Soviets have been experimenting with a test vehicle that is apparently a scale model of a larger, manned space plane. This vehicle has been orbited unmanned on four occasions, landing in water each time. Similar in appearance to the earlier US Dyna Soar craft, this plane's possible missions include reconnaissance, crew transport, satellite repair and maintenance, and ASAT operations. It could also be used as a manned space station defender. A clue to its purpose is found in a 1965 Soviet definition of antispace defense: "A component part of air defense. The main purpose of antispace defense is to destroy space systems used by the enemy for military purposes, in their orbits. The principal means of antispace defense are special spacecraft and vehicles (e.g., satellite interceptors), which may be controlled either from the ground or by special crews."

Soviet Space Launch Vehicles



	SL-3	SL-4	SL-6	SL-8	SL-11	SL-12	SL-13	SL-14
LIFT-OFF WEIGHT (KG)[1]	290,000	310,000	310,000	120,000	180,000	680,000	670,000	190,000
LIFT-OFF THRUST (KG)[1]	410,000	420,000	420,000	150,000	280,000	900,000	900,000	280,000
PAYLOAD TO 180 KM (KG)[1]	6,300	7,500	2,100	1,500	4,000	—	19,500	5,500



	MEDIUM-LIFT LAUNCH VEHICLE	HEAVY-LIFT LAUNCH VEHICLE	HEAVY-LIFT LAUNCH VEHICLE WITH 6 OR MORE STRAP ON BOOSTERS
LIFT-OFF WEIGHT (KG)[1]	400,000	2,000,000	
LIFT-OFF THRUST (KG)[1]	600,000	3,000,000	4,000,000
PAYLOAD TO 180 KM (KG)[1]	15,000+	30,000	150,000

[1] Approximate.
[2] In final stages of development.

The Soviets have openly discussed their plans for ambitious planetary exploration in spite of their apparent decision not to match US lunar expeditions. In 1992, the condition for a launch to Mars will be favorable, and the Soviets are considering a manned expedition to that planet at that time. They have stated that the recent manning of the SALYUT space station for increasingly longer periods of time is to simulate the time it would take to conduct a Mars mission. This timeframe also coincides with the 75th anniversary of the Bolshevik Revolution and with the 500th anniversary of Columbus' discovery of the New World. Such an expedition would add great prestige to the Soviet Union and would further demonstrate the capability of its space technology.

Military Space Systems. Soviet space systems dedicated to military missions include satellites that perform reconnaissance, missile-launch detection and attack warning, command and control, and ASAT operations. Dual-purpose satellites that perform some civilian functions are used for communications, navigational support, and weather prediction and monitoring. The US has no counterpart to Soviet ocean reconnaissance satellites, the Electronic Intelligence Ocean Reconnaissance Satellite (EORSAT), or the nuclear-powered Radar Ocean Reconnaissance Satellite (RORSAT). Their mission is to detect, locate, and target US and Allied naval forces for destruction by antiship weapons launched from Soviet platforms. These systems track naval and merchant shipping. Four such satellites were launched in 1984, two of which were of the same type (RORSAT) that crashed in 1978, one spreading radioactive debris across northern Canada.

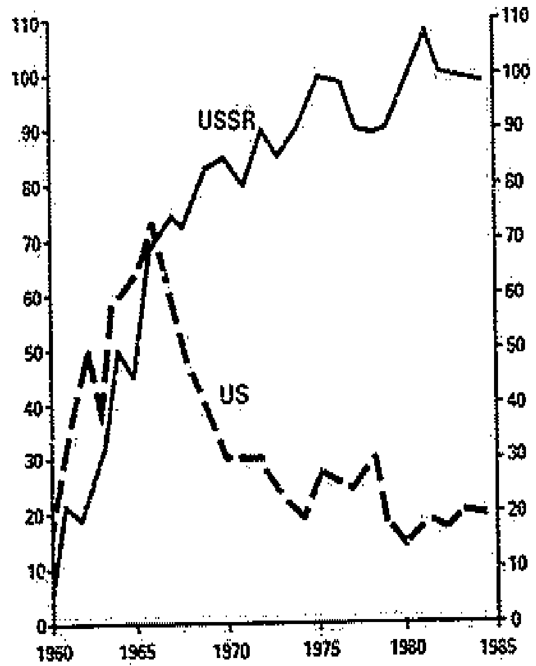
The Soviets have recently employed a new radar-carrying satellite system. Designed for mapping ice formations in polar regions, these satellites will greatly enhance the ability of the Soviet Navy to operate in icebound areas. The system can be used to aid in the navigation of northern sea routes to assist in moving naval ships from construction yards in the western USSR to new ports in the Pacific.

The launch rate of satellites to geostationary orbits has risen in recent years. In the period 1974-78, one to two launches per year were conducted. In 1979, the rate increased to five per year, and eight launches occurred in 1984. These satellites are presumed to be for communications, although not all may have been for that purpose. The Soviets have filed their intent with international organizations to place almost 40 satellites in 21 different positions in the geostationary belt. Many of these satellites are years overdue, but the Soviets are apparently determined to fill the announced slots. The Soviets are also in the early stages of developing a satellite system called GLONASS, which, when fully developed, should provide the Soviets with accurate positioning data worldwide.

For the most part, Soviet satellites do not have lifetimes as long as those of their US counterparts. This is especially true of their reconnaissance platforms, necessitating frequent launches of replacements. However, the Soviets have shown great flexibility in maintaining these systems in orbit, augmenting them with extra satellites as warranted by changing situations. They have demonstrated a launch surge capability that could be a distinct advantage in time of hostilities. In 1984, the Soviets orbited a

reconnaissance satellite that stayed in orbit for longer than previous ones. This could indicate a new system or an advanced modification of an old one, demonstrating their increasing sophistication and capabilities.

US and Soviet Space Launches



In late 1984, a new Soviet auxiliary ship was seen arrayed with extensive radomes and antennae. The ship, named after the first commander of the Strategic Rocket Forces, Marshal M.I. Nedelin, appears to be a new space and missile support ship capable of a variety of missions, including support to strategic forces worldwide. On its maiden voyage the NEDELIN transited directly from the Baltic to the port of Vladivostok, the headquarters of the Pacific Ocean Fleet. This ship will significantly upgrade the Soviet capability to test new generations of missiles as well as support the expanding Soviet space program. The NEDELIN joins a growing fleet of Soviet space support ships that provide assistance to manned and unmanned missions. An additional ship of the NEDELIN-Class is under construction.

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C.2 THE MANAGERIAL AND BUDGETARY RELATIONSHIP AMONG THE VARIOUS AMERICAN STRATEGIC DEFENSE ACTIVITIES

C.2.1 CONGRESSIONAL REPORTING REQUIREMENTS

The following is submitted in response to the Congressional request on "...the managerial and budgetary relationship among the various American strategic defense activities, including the impact of the Strategic Defense Initiative on the Air Defense Master Plan, and the impact of the Strategic Defense Architecture Study on present and prospective strategic anti-submarine warfare programs."

C.2.2 FOCUS OF THE STRATEGIC DEFENSE INITIATIVE

The Strategic Defense Initiative is focusing on defenses against ballistic missiles because the speed, short warning time, and great destructive capability of ballistic missiles pose a greater threat to stability than do slower-flying systems such as bombers and cruise missiles.

The technologies that are becoming available today may offer the possibility of providing a layered defense utilizing capabilities which can attack ballistic missiles in all stages of their missile trajectory. This concept of a layered defense could be extremely effective by providing several opportunities to destroy attacking missile warheads before they reach the territory of the United States and that of its Allies.

C.2.3 DETERRENCE AND STABILITY

Defenses against ballistic missiles can have a highly beneficial effect on deterrence and stability in three quite specific ways. First, by demonstrating the ability to destroy the bulk of an attacker's ballistic missile warheads, an effective defense can undermine a potential aggressor's confidence in his ability to predict the likely outcome of an attack on an opponent's military forces. No aggressor is likely to contemplate initiating a nuclear conflict, even in crisis circumstances, while lacking any confidence in his ability to obtain a successful outcome.

Second, with the ability to effectively destroy attacking ballistic missiles, and thus rendering them "impotent and obsolete" for military or political purposes, such defenses also can eliminate the potential threat of first-strike attacks.

Third, by reducing or eliminating the utility of Soviet shorter-range ballistic missiles which threaten Europe, defenses can have a significant and specified impact on deterring Soviet aggression in Europe. Soviet SS-20s and shorter-range ballistic missiles provide overlapping capabilities to target all of NATO Europe. This capability is combined with a Soviet doctrine that stresses the use of conventionally-armed ballistic missiles to initiate rapid and wide-ranging attacks on crucial NATO military assets throughout Europe. The purposes of this tactic would be to reduce significantly NATO's ability to resist the initial thrust of a Soviet conventional force attack and to impede its ability to resupply and reinforce combatants from outside Europe. By reducing or eliminating the military effectiveness of such ballistic

missiles, defensive systems have the potential for enhancing deterrence not only against strategic nuclear war, but against nuclear and conventional attacks against Europe as well.

Finally, in conjunction with air defenses, effective defenses against ballistic missiles could help reduce or eliminate the apparent military value of nuclear attack to an aggressor. By preventing an aggressor from destroying a significant portion of our country, an aggressor would have gained nothing by attacking in the first place. In this way, effective defenses could reduce significantly the possibility of nuclear conflict.

Because an effective defense against Soviet ballistic missiles is the more difficult technology to achieve (according to expert scientists and engineers), and because ballistic missiles are potentially more destabilizing, priority is being given to the examination of those technologies that might prove effective against this threat. In view of the current Soviet nuclear force structure which emphasizes ballistic missiles, not air breathing forces, the deployment of a robust air defense system would occur only in conjunction with the deployment of an effective defense against ballistic missiles.

C.2.4 AIR DEFENSE MASTER PLAN

The purpose of Air Defense Modernization is to address existing critical deficiencies in the U.S. ability to detect and defend against bomber and/or cruise missile attacks. The planned objective and on-going thrust of Department of Defense North American Air Defense (NAAD) modernization efforts is to: field modern radar and related C^3 systems to provide contiguous coverage around North America; improve fighter interceptor capabilities; and improve operational planning to utilize new resources effectively to ensure significantly improved detection, attack assessments and engagement capability.

Together with Canada, the U.S. is modernizing the obsolete radars that provide surveillance of the northern approaches to North America. The new radars, known as the North Warning System, will fill gaps in existing coverage, enable the U.S. to detect low-flying aircraft, and be cheaper to maintain than the present system.

C.2.5 STRATEGIC AIR DEFENSE

Because it is still in the research phase, the Strategic Defense Initiative has a minimal relationship with the near-term air defense improvement effort. As we look to the year 2000 and beyond, however, SDI is expected to have a much greater impact. Study efforts will not ignore the relationship between the research of the Strategic Defense Initiative and strategic air defense. Strategic air defense requirements are currently under review and continuing progress in the area of the Strategic Defense Initiative will permit the addressing of even more comprehensively the interrelationship between SDI and strategic air defense.

C.2.6 ANTI-SUBMARINE WARFARE (ASW)

One of the principal missions in war is protection of the sea-lines of communication which tie the U.S. to its Allies, U.S. forces, and many of the resources essential to the U.S. economy and to its ability to continue to defend the U.S. and its Allies.

Countering the Soviet submarine threat requires a layered strategy that both maximizes enemy attrition and affords a high level of protection for U.S. naval forces. The best means of neutralizing enemy submarines is to engage them in forward areas and at barriers—before they come within range of attacking our forces. For this, the U.S. relies primarily on attack submarines and long-range P-3 patrol aircraft supported by undersea surveillance systems. Enemy submarines that escape forward sweeps and penetrate the U.S. ASW barriers must contend with a layered defensive screen surrounding its naval task forces and convoys. Within this layered defense system, long-range protection is provided by land- and carrier-based patrol aircraft and by attack submarines operating in a direct-support role. At shorter ranges, protection is provided by formations of surface combatants equipped with passive and active sonar systems and by torpedo-armed antisubmarine helicopters.

Nuclear-powered attack submarines (SSNs) remain a key element of the U.S. ASW defense-in-depth strategy and are an integral part of our forward offensive strategy, especially for anti-submarine operations.

The need to counter the Soviet submarine threat will continue to remain a high priority for the indefinite future. This requirement is generally independent of air defense modernization efforts. Recent developments do, however, provide one area of common concern. The impending Soviet deployments of new, long-range nuclear sea-launched cruise missiles (SLCM) provide added importance to our efforts in this key mission area. The magnitude of existing threats from Soviet ballistic missiles, however, far exceeds the threat from near- or mid-term SLCM deployments. The U.S. is exploring measures which could become meaningful should it develop an effective defense against ballistic missiles, including additional warning and defensive measures.

C.3 THE RELATIONSHIP OF OTHER PROGRAMS WITH SDI

C.3.1 CONGRESSIONAL REPORTING REQUIREMENTS

The following deals with the Congressional requirement for a report on "...the relationship of other missile and space defense programs, and other directed energy programs, that have not been included in the SDI, with the SDI program."

C.3.2 PROGRAMS NOT INCLUDED IN SDI

Tables C.1 and C.2 are from the Congressional Budget Office Report to the Senate Foreign Relations Committee, Subcommittee on Arms Control, Oceans, International Operations and Environment, May 23, 1984.

TABLE C.1

EXAMPLES OF PROGRAMS NOT INCLUDED IN SDI BY THE BROADER DEFINITION
(IN MILLIONS OF DOLLARS OF BUDGET AUTHORITY)

PROGRAM ELEMENT	NAME	1984	1985	1986
64406F	Anti-Satellite (ASAT) R&D[1]	202.7	133.0	149.9
63226E	Air Defense Surveillance Warning (Teal Ruby)	32.2	31.0	25.0
63401F	Research on Satellite Power and Survivability (Advanced Spacecraft Technology)	0	6.9	9.7

ASAT research and development funds could be regarded as part of a comprehensive defensive program to negate surveillance satellites. ASAT technology could be used in the development of a ballistic missile defensive system.

C.3.3 ASSOCIATED RESEARCH NOT INCLUDED IN SDI FUNDING

TABLE C.2

EXAMPLES OF ASSOCIATED RESEARCH NOT INCLUDED IN SDI FUNDING
(IN MILLIONS OF DOLLARS OF BUDGET AUTHORITY)

PROGRAM ELEMENT	NAME	1984	1985	1986
63605F	Advanced Radiation Technology	46.7	5.0	19.7
62707E	Particle Beam Technology	30.9	17.4	21.5
62307A	Laser Weapons Technology	20.0	21.1	21.4
63424F	Missile Surveillance Technology	0	3.0	11.6
65806A	DoD High Energy Laser Facility	37.1	32.8	20.2

Most of the activities in directed energy weapons have tactical applications such as surface-based particle beam research, that was left out of SDI since it is unlikely that a strategic defensive system will utilize surface-based particle beam weapons.

Other activities, such as Missile Surveillance Technology supports the Advanced Warning System which could be part of a strategic defensive system. Some of the Army BMD monies outside SDI in FY 1986 seem to be related to SDI technology development, but need to be checked out in Descriptive Summaries.

C.4 LONG-TERM COSTS OF STRATEGIC DEFENSES

C.4.1 CONGRESSIONAL REPORTING REQUIREMENT

This section addresses the Congressional requirement for a report on "...the projected long-term costs of strategic defenses, including research, testing, procurement and operations and maintenance costs on a year-by-year basis of the various systems and technologies currently in service and under study."

C.4.2 LONG-TERM COSTS OF STRATEGIC DEFENSES

The SDI is a broadly based research program that is designed to determine whether newly emerging technologies could support an effective defense against ballistic missiles in the future. At this time, the actual capabilities of these technologies are not sufficiently defined to provide a sufficient basis on which to fashion a likely defense system configuration. Until SDIO has a more complete picture of what an effective defense system might look like--as well as the technologies that would form the constituent parts of such a system--it will not be possible to determine the full range of long-term costs that might be associated with a potential future strategic defense. One of the results of the SDI program will be the data necessary for an assessment of the long-term costs of a defensive system.

At this point, what can be provided is the cost of the research program itself, that is estimated to be approximately $26 billion over the next five years, which includes $1.4 billion (appropriated) in FY 1985; $3.7 billion (requested) in FY 1986; and $4.9 billion (estimated) in FY 1987. Additional costs that would stem from a decision to enter into full-scale engineering and deployment of a defensive system, as well as operations and maintenance of such a system, would depend on the particular technologies selected, the capabilities of those technologies, the systems in which those technologies would be deployed, and the strategic environment at the time of deployment. Because this information will not be available until more is known about the potential of the technologies involved and the course of future arms control negotiations, long-term defense cost estimates are not feasible at this time.

Cost estimates for currently available defensive systems or components, like the retired Safeguard ABM system or various ABM test radars are available, but because these systems bear little resemblance to a potential advanced defense system, such estimates cannot provide a useful basis for estimates of future advanced defense system costs. Moreover, were the U.S. to build a defense system today based on Safeguard and similar technologies,

the hardware, production techniques and costs would likely be substantially different from those used over a decade ago.

The Department of Defense realizes fully the importance of this question and appreciates that it is central to any future national decision whether to develop and deploy defensive systems. As cost estimates are generated in the future, they will be made available to the Congress in a timely manner.